SCIENTIFIC FARMING

MADE EASY.

FLETCHER.

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MADE EASY:

OR,

THE SCIENCE OF AGRICULTURE

REDUCED TO PRACTICE.

BY

THOMAS C. FLETCHER,
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"If practice without theory be contemptible; theory, professing to teach without practice, is foolhardy."

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TO

JOB BRADSHAW, ESQ.

Proprietor and Editor of the "Nottingham Journal,"

AND TO THE

FARMERS OF NOTTINGHAMSHIRE;

ALL OF GOOD THAT THE FOLLOWING PAGES MAY CONTAIN

IS TO THEM JUSTLY AND MOST RESPECTFULLY

Dedicated;

Seeing that it is entirely owing to the facilities afforded by the former, and the kind and indulgent reception by the latter, of a series of Letters published in the *Nottingham Journal* some fifteen years ago, under the Signature of "O. P. Q." that the Author has been led to study the best means of applying the Science of Agriculture to practice. And he humbly hopes that whatever knowledge he may have acquired from the study of a science which has afforded so much pleasure to himself, may not be entirely without use to others.

LONDON, *September*, 1860.

ERRATA.

Page 49, line 12 from the top, *for* "rich mould," *read* "dry mould."
" " " 6 " bottom, *for* "farmyard dung," *read* "compost dung."
" 59, " 19 " top, *for* "it has," *read* "they have."
" " " 20 " " *for* "its," *read* "their."
" 70, " 3 " " *add* "In purchasing beware of factory flue-dust."
" 113, " 10 " " *for* "to the side," *read* "by the side."

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PART I.

THE SOIL AND ITS FERTILIZERS.

SCIENTIFIC FARMING MADE EASY.

CHAPTER I.

INTRODUCTORY.

"What, another book on Farming?" some peevish old gentleman may possibly exclaim, on reading our title-page; "why publish more books on agriculture? we have had plenty of such trite stuff of late; besides, what can authors know about farming? It is not to be learned from books; it can only be acquired by long laborious practice. Don't tell me of a man delivering his precepts upon agriculture from his study, surrounded by books, without even pretending to have had experience; propounding new theories and laying down new laws as though they were established axioms, when, in fact, they are for the most part only mistakes, copied from other wiseacres who have preceded him."

To such objectors the author would say: his object has, throughout, been not so much to propound new as to test existing theories by practice, and, by collecting together a number of well-authenticated experiments and placing them by the side of the theories they were intended to test, to give thereby to the agricultural community the full benefit of the combined experience

of those intelligent and diligent inquirers who have incurred the trouble and cost of investigating the principles involved in the discoveries of others.

Although science has done much, no one is more ready than I am to admit that farming can neither be taught wholly by chemistry, geology, mechanics, mathematics, nor any other abstract science whatsoever. *To learn farming, a man must farm.* Theory may guide and assist practice; but practice alone can test the value of theory. A wheelwright, before he begins to build a wagon, will form some plan for its structure, and not till then will he proceed to put it in practice. All plan is theory, and everything produced by the skill and ingenuity of man is nothing more than theory reduced to practice. Theory is not, as some foolishly imagine, *opposed* to practice, but performs the office of a lamp to enlighten its path; and, although the light shed may not be equal to that of broad day, still it is better than no light at all. Man is made for the acquirement of knowledge, and has a natural curiosity to learn the reason of everything; and why should he not indulge a craving that will both amuse and bring forth instruction? I do not presume in this work to embody a complete theoretical system of farming, a subject far beyond my reach. I disclaim, also, the idea of being either exclusively scientific or original; my aim is to be practically useful, and to offer to my readers the result of much reading, observation, and actual experience; and, if impelled to indulge occasionally in theoretical speculation, I shall venture only to introduce into these pages such views as have an immediate bearing and influence upon practice. These will be readily understood by every farmer who joins some reading and

reflection to experience, and may, I trust, in cases of doubt, help to direct his operations.

As the object of all farming operations is to produce food and clothing, and as the objects of food and clothing are to sustain life and strength, and to produce that degree of temperature in the bodies of men and animals as will best enable them to perform their required amount of labour, so is it the object of this work to point out how, and in what way, these conditions may be obtained at the least expenditure of labour, money, and time.

In all that appertains to MANURES, their constituents and process of manufacture, I have stated nothing but what has been borne out by my own actual experience and that of numerous friends, spread over a long series of years, and tested under many and various adverse circumstances. For that portion of the work devoted to ARTIFICIAL FOODS and CATTLE-FEEDING, I can claim no other credit than that due for much care and labour bestowed in compiling and comparing a series of well-combined and carefully-conducted experiments, made by some of the most eminent and successful grazing farmers of the present time.

The directions given for analyses are not intended to be taken as scientifically and decimally correct; for such exact details the works of Rose, Freseinus, and Johnston should be consulted; but they are such as may well serve for practical purposes, while, at the same time, they possess the advantage of being so simple as not to require elaborate apparatus, and may be performed by any farmer at his own fireside.

The TABLES introduced are taken from various authentic sources, and I feel much pleasure in acknowledging the assistance I have derived from the writings

of Voelcker, Anderson, Sibson, Sprengel, Hodgson, Way, and others; and if the authorities are not always individually referred to, the omission is solely to be attributed to want of space.

Before proceeding to the more practical portion of my work, I propose to offer a few observations upon what appears to be one of the great features of the age: viz., the application of science to practice.

"PRACTICE WITH SCIENCE" is the very appropriate motto of the "Quarterly Journal of the Royal Agricultural Society;" and truly may it be said that science, during the last fifty years, has done more for agriculture than the unskilled practice of many previous centuries. Yet, obvious as this may seem, there are many, even now, who draw the same line of distinction between science and practice as between mere speculation and experience, and, with a bigoted adherence to old ways, obstinately avert their eyes from all modern improvement, and persist in looking at farming operations solely through their grandfathers' spectacles. It is this blind adherence to old prejudices that has prevented the science of agriculture from progressing with the same rapid strides as those that so wonderfully attest the growth and power of our manufactures, and the vast augmentation of our national wealth. And yet there is no trade or occupation which admits of experiments being so easily and inexpensively made as that of a farmer; seeing that, for all useful purposes, an experiment made upon 100 square yards is quite as demonstrative as one made upon as many acres. I have often heard it remarked that a really good register of well-authenticated experiments would be of the greatest value; and I cannot but think, that if a number of farmers were to agree among them-

selves to make various experiments, and have the results carefully combined and noted down, such a record would form an invaluable guide for future action. Were this system thoroughly carried out, a farmer would no longer be content with his land barely producing him four rentals, for he would see, by the experiments made by his neighbour, that it is capable of being made to produce as much as eight. Nor would he continue to grow a tall rank wheat-straw, with a light yield of grain, if he saw his neighbour growing a strong, short, glassy straw, firmly supporting a well-filled ear. Experience has shown that this can be done, and that, too, in the face of a bad season; and we all know that what has been done once may be done again.

There is no good reason why the farms of England should yield crops so greatly inferior in comparison with what our market-gardeners produce. Professor Playfair, a reliable authority, has stated that the value of £250 has been produced from a single acre of market-garden ground in one year. Why, then, should not our farms be made comparatively profitable? That they are not so we all know, and the reason is obvious. The market-gardener is generally content to cultivate no more ground than his capital is equal to; while the farmer, on the other hand, is continually grasping at more land, when he has barely capital sufficient to farm properly what he already occupies. It cannot be too strongly urged as a truth, that no tenant farmer, straitened for capital, can ever farm well or profitably; and for parties in this predicament there is but one mode of extrication, which they ought not to lose a moment in adopting; viz., to restrict themselves to half the number of acres. By so doing, they would not

only double their acreage capital, but lessen their expenditure, and be able to concentrate their energies with greater advantage. Moreover, by decreasing the competition for land, rents would necessarily become more moderate, and they would be thereby placed in a better position to secure the value of their permanent improvements than they are now. By resolutely adopting this prudent course, we should hear no more of such idle excuses as "Can't afford it," when improvements were suggested. We should then no longer look with pity on a solitary individual undertaking the labour of a 20-acre field; but we should see some half-dozen hands employed upon it, in the various duties of draining, fencing, scouring, cleaning, and other operations, all essential to a good crop. True, the small farmer would have to pay more for labour; but, on the other hand, he would have to pay less for poor, police, and county rates; he would obtain larger crops, and thus be enabled to produce a larger quantity of beef and mutton, besides procuring thereby an extra quantity of manure, and consequently the saving of many pounds annually in the purchase of artificial fertilizers. In short, he would gain on all sides, to a much larger extent than would counterbalance the cost of extra labour employed.

Mr. Mechi observes—and upon such a subject as this he is no mean authority—that "*the quantity of meat made on a farm per acre, determines the quantity of corn grown.*" And he adds: "By putting a few questions to a farmer, I can almost immediately arrive at a conclusion as to his position, without visiting his farm. The first question would be, 'How much meat do you make per acre over the whole acreage of your farm?'"

This question has been solved by Mr. Thomas Dyke

Acland, in the Royal Agricultural Society's Journal, vol. xi. p. 666. He there shows that the largest corn-growing farmer in Norfolk, a most successful man, produces 4½ score of meat on *every acre* of his land. Compare this with the general average of the farms of this kingdom, which certainly do not produce one score pounds of meat per acre. The more meat you make, the more manure you produce and the more corn you grow. The common labourer is the best evidence on this point. With his patch of ground, about one-eighth of an acre, he knows that unless he keeps a pig to make manure, he cannot expect a crop. Therefore he fattens one pig, which consumes three sacks, or twelve bushels, of barley-meal, which at 7 lbs. of meal to 1 lb. of meat, would be 84 lbs. of meat, or four score on the one-eighth of an acre, or over 32 score per acre.—(*How to Farm Profitably*, p. 6.) While, with respect to corn produce, let us take a lesson from some of the cottagers in the county of Lincoln; and the fact I am about to state may be useful to those who may object to the comparison between farm and market-garden produce. Many of these cottagers, by means of their pollard-fed pig and spade-culture, produce 14 bushels of wheat to the rood, or 56 bushels per acre, while our national corn-growing average hardly exceeds 20 bushels per acre.

In spite, however, of much prevailing ignorance, considerable progress in agricultural improvement, as we have already observed, has been made during the last half-century; although, it must be confessed, that scientific farming is still in its infancy. And, while admitting that the produce of the soil of England has been nearly doubled during the last fifty years, it

cannot be questioned that it is capable of being made to produce a still far greater amount of food; and this mainly by extra manure, additional labour, and a judicious application of science to practice; and I do not hesitate to say, that, until the farmer has done this, he has no right to look for public sympathy on the plea of either light crops or low prices. A light grain-crop is generally attended by a rank straw; and a rank and overgrown straw is in nearly all cases the result of either ignorance or indolence, or both combined, and may be easily remedied by the substitution of skilled culture for the one, and increased energy for the other.

I have before observed that the proper office of science is to direct and guide practice, and place it upon an intelligible basis, by pointing out the connection between cause and effect, and to explain how certain operations necessarily lead to certain results. Practice without such a guide, is at best but a kind of groping in the dark, a tedious, expensive, and uncertain process, resulting in a confused mass of facts and impressions, which every simpleton hugs to his heart as an idol, calling it "experience." That experience is a good schoolmistress nobody denies, and she would be a much better one were her terms not so high; moreover, if she gave reasons for her teachings, she would become invaluable; but this she does not pretend to do. Practice in itself, unfortunately, explains nothing, and as its results, although obtained under comparatively similar conditions, frequently differ, it is utterly beyond its unreasoning power to explain the cause of this difference. Here science steps in, and by means of chemistry, clears up all that before was dark and mysterious; it teaches us the nature and the properties of different

substances; it shows the changes which these substances are continually undergoing, and explains why such changes occur, and the way in which they are brought about.

It is not expected, nor necessary, however, that every farmer should become an expert chemist; such an attainment, however desirable in itself, would be, with his daily occupations, scarcely practicable; but it is absolutely necessary for his own interest that he should have such a practical acquaintance with chemistry as would enable him not only to apply right things to their right uses, but also to protect himself against fraud and imposition in the purchase of such artificial substances as he may require for fertilizing his soil, or feeding his cattle.

The advantages conferred upon agriculture by science may be thus briefly recapitulated:—An accurate knowledge of the component parts of the various plants required for food of both man and beast, also in what they are alike, and wherein they differ; and further, what portion of their nourishment and substance they derive from the atmosphere and what from the soil;—how the juices required for their support are elaborated, and how taken up; and how certain substances in the soil have heat-giving, or fat-forming, and others, flesh-forming properties.

We may here remark that it is to the scientific researches, and the unwearied industry of such men as Lawes and Gilbert, that the agricultural world has not been led astray by some of the dazzling theories of Liebig. Thanks to the efforts and skill of these able men, the science of fertilization is now reduced to a recognized system, and the farmer has a reliable guide to direct him in all his manuring operations.

Had science, indeed, done nothing more for the benefit of farmers than to provide checks upon the frauds so frequently practised in the manure-market, it would have been amply sufficient to entitle Messrs. Lawes and Gilbert to the lasting gratitude of the agricultural community. But science has done much more than this: it has pointed out simple methods by which a farmer may, at but little trouble, not only detect adulteration, but estimate the comparative value of the different oil-cakes and other artificial foods he may require for feeding his stock. And it remains only to have this knowledge generally diffused, to enable every man engaged in agriculture to increase his produce and thereby augment his profits.

CHAPTER II.

THE HABITS AND FOOD OF PLANTS.

The resemblance of plants to animals is much greater than their respective appearances would lead us to suppose. All animals possess the powers requisite to enable them to support the state of being into which they have been called. These vary according to their nature, species, and the kind of food required for their support. This is precisely the case with plants: they are as amply endowed with the powers necessary for preserving vegetable life, as animals are for preserving

animal life. To what other cause than an innate vitality* can we attribute the springing of the seed, the motion of the sap, the production of leaves, flowers, fruit, &c.? These proceed as clearly from a vital power in the plant, as the beating of the heart, the circulation of the blood, &c., proceed from a vital power in animals. What is the stem of a plant, but a bundle of parallel tubes to convey the sap from the root to the leaves and return it to the root again, and corresponding in every particular to the arteries and veins in the animal? The roots, stems, and leaves of plants are all full of minute pipes for carrying the sap to every part of the vegetable structure, and these again exactly correspond with the chyle-ducts of the human frame; and in short, there is not an argument for the one that is not equally conclusive for the other.

Then as to the power of locomotion: this power is certainly more perfect in animals,—they require it to enable them to obtain food; but plants possess such a share of it as is necessary for the same purpose: they grow both upwards and downwards, and in their progress to maturity, they are continually occupying new parts of space. True, plants cannot, like animals, move out of harm's way; but it is curious to observe how they exert that share of locomotion they are endowed with to avoid harm. The sensitive plant shrinks back and folds its leaves upon the slightest touch, as a snail retires into its cell. Another species of the same plant

* Baron Liebig seems inclined to dispute, or at least to ignore, the existence of vital action in plants; but as he has not accounted for the powers they exercise in any other way, he must pardon me if I continue to call it "vital action" till furnished with a more appropriate term.

has acquired the name of "Fly-trap," from the fact, that if a fly perch upon one of its flowers, it closes instantly, and crushes the insect to death. The nettle never fails to sting the hand that touches it. Nor is there anything more interesting and beautiful in botany than a contrivance, visible in many plants, to take advantage of good weather and protect themselves from bad. They open and close their flowers and leaves, in different circumstances; some open to receive rain, some close to avoid it. Thus all the trefoils may serve as a barometer to the husbandman: they always contract their leaves on an impending storm.

A plant has also the power of directing its roots so as to obtain the utmost nourishment possible from the soil. Some years since I saw a plane-tree, about five-and-twenty feet high, perched on the top of a wall belonging to an old ruin in Scotland. Not having sufficient nourishment in that barren situation, it had some years before directed its roots down the side of the wall, till it reached the ground, at least ten feet below; and now the nourishment afforded to these roots during the time of their descending is amply repaid, the tree having every year since that time made vigorous shoots. From the top of the wall to the surface of the earth, I did not observe that these roots had thrown out a single fibre, but they are now united into a pretty thick root. Plants also, when forced from their natural position, are endowed with a power to recover it. The hop, the scarlet-runner, and other plants of like nature, have a propensity for twisting themselves round a stick, and this they do from West to South. If one of these plants be untwisted and twined in an opposite direction and tied there, in a few days it will wither and die; if

left loose, it will untwist itself and return to its natural position in the course of a single night. The leaves of all plants also have an upper and under surface which never vary. Twist a branch so as to invert its leaves, and fix it in that position, if left in any degree loose, it will gradually untwist itself until its leaves regain their natural position. What more could an animal do under similar circumstances? A root of a tree meeting with a ditch in its progress is laid open to the air,—what follows? It alters its course like a rational being, dips into the ground, finds its way under the ditch, and rises on the opposite side to its wonted distance from the surface, and then proceeds in its original direction.

This comparison between plants and animals might be carried much further; but, however interesting in itself, it would have but little bearing upon the subjects we have to consider. The following must therefore suffice for the present. There are powers in every animal to struggle for health by expelling diseases. All that a surgeon can do in the case of a broken bone, is to restore it to its natural position. It is Nature that performs the cure by pouring into the broken part a liquid matter, which hardening into bone, unites the parts firmly together. The plant possesses similar powers. A wound in a tree is cured like a wound in an animal; the separated parts unite, a gum-like substance surrounds the wound, and after a time that part becomes covered with bark as before. If part of a branch or root be cut off, the want is supplied by a number of small shoots issuing from the place where the cut was made.

As plants doubtlessly were originally created of many species, each species has powers peculiar to itself, by

which the different species are kept distinct; and by this means uniformity is preserved amongst individual plants of the same species. These powers, variously modified in every different species, are exerted in the propagation of new plants with leaves, flowers, seed, &c. peculiar to each species. And as a perfect agreement between the internal and external frame of plants, as well as of animals, is undoubtedly the plan of Nature, it may be taken for granted, that each external part contributes to the well-being of the plant, and that any alteration would be injurious.

Passing over the subject of propagation, as not having any particular bearing upon agricultural pursuits, let us now proceed to consider,—

The Food of Plants.—There is perhaps no branch of natural philosophy in which imagination and conjecture are more apt to freely indulge than in that which treats of the food of plants. Scientific men have, at one time or another, propounded various theories upon the subject; and provided they can invest them with a plausible exterior, they do not deem it necessary to submit them to the rigid test of facts and experiments. No! that would be too troublesome and perhaps inconvenient, seeing the touchstone of experiment might lead to results at variance with the theory, and then would a large amount of imagination be "cut to waste." Each theory-monger of this class, therefore,

> "Erects a shrine and idol of his own,
> Some leaden calf ———"

and modestly calls upon thinking men to fall down and worship as a fact, that which, upon examination, turns out to be nothing more than an ingenious fallacy. One

of the latest of these mistaken theories I met with a short time ago thus gravely set forth : " Oil and salt are found in all plants ;—*ergo*, oil and salt in the soil is the proper nutriment of plants ;—*ergo*, oil and salt is the best manure to promote vegetable produce." To show the absurdity of this reasoning, let us push the matter a little further, and say,—As blood is found in all animals, and as a cow is an animal, *ergo*, blood is the best food for a cow. Absurd as this theory must appear to every thinking man, not a few have been led astray by it, and among the number the late Dr. Hunter, of York, who was so completely convinced in his own mind of its correctness, that he absolutely proposed to bring out a manure composed of oil and salt, and which was intended to be called the " Oil Compost." The Doctor did not remember that neither oil nor salt could be taken up by plants in their crude state, and that when mixed, one would assist the other in resisting decomposition.

Passing over other theories equally absurd, I venture to lay before my readers, what I conceive to be, if not the true theory, still one that is based upon sound principles, and capable of being supported by rational arguments. From the observations I have been enabled to make, I am induced to think that the following propositions may be regarded in the light of axioms :—

1. All plants derive their support from certain juices and gases imbibed through their roots and leaves.
2. These juices and gases are, by an internal process, converted into sap.
3. This sap is in continual motion, ascending during the heat of the day, and descending during the cold of the night.
4. The sap of all plants, like the blood of all animals,

is identical,* and it is by this sap that the life of plants is sustained.

These propositions being admitted, it follows that every plant must be endowed with the powers necessary, first, to imbibe juices; next, to convert the juices imbibed into sap; and lastly, to convert that sap into its own substance. With respect to the two first powers, all plants appear to be similar; the difference of species being carried on by the last power only,—that of converting the sap into the substance of the plant; and hence arise the peculiar texture, colour, smell, and taste in each species: and numerous experiments are on record which serve to prove that, however different the juices may be that are imbibed by plants, the sap into which these juices are converted is the same, or nearly the same, even in plants of different species. "Thus," observes the late Dr. Hunter, "a mass of innocent earth can give life and vigour to the bitter aloe and to the sweet cane, to the cool house-leek and to the fiery

* The sap of plants has heen found, by numerous experiments, to be nearly the same in whatever soil the plant may grow. Homberg filled a pot with earth mixed with saltpetre; he also filled another pot with pure earth well washed. The cresses that grew in these pots were precisely of the same nature, equally alkalescent; what grew in the first pot was as little acid as what grew in the second. In other two pots prepared in the same manner, he planted fennel, an acid plant: the difference of the earth made no difference in the two plants. If we can judge of sap from what it exudes from the plant, it is nearly the same in different species. Dr. Hales collected the liquor exuded from trees of different kinds: it was very clear, and its specific gravity was nearly the same as that of common water, and no difference of taste could be perceived in the different liquors. And although plants are distributed by nature into classes distinguishable by light, no class could be preserved distinct, if the juices imbibed by it had any influence to vary its nature.

mustard, to the nourishing wheat and to the deadly nightshade." In what manner or by what means these changes are produced will, in all likelihood, for ever remain a mystery: they depend on energies impenetrable by the human eye, and, as yet, beyond the reach of experiment. It is the province of agriculture to cultivate soils in such manner as to furnish the juices mentioned in plenty; the rest may with safety be left to Nature, who never errs in her operations. Before the farmer, however, can be placed in a position to supply the soil with those ingredients best adapted for producing the juices before spoken of, it is essentially necessary he should know of what those juices are composed.

Here chemical analysis comes to his aid. From it we learn that all plants contain two different classes of matter, the one combustible, and the other incombustible. Their combustible portion is chiefly, but not entirely, derived from the atmosphere, and consists of carbonic acid, water, and ammonia; the incombustible portion, that is, the portion left as ash after burning, is composed of phosphoric acid, potash, silicic and sulphuric acids, lime, magnesia, iron, and chloride of sodium (common salt); the former being termed the organic,* and the latter the inorganic constituents of plants. These, then, in their respective proper pro-

* "Organic chemical compounds are such as enter into the construction of the different organs of plants and animals, as well as such substances as are produced during the living action of these organs."—(CHAMBERS'S *Chem.*, p. 266.) The foregoing are chiefly derived from the air, and are composed of *oxygen, hydrogen, carbon,* and *nitrogen;* and some also contain *phosphorus* and *sulphur.* The inorganic substances are *lime, magnesia, silica, potash, common salt, soda, phosphoric acid,* and *sulphuric acid.* These, or nearly all of them, are derived from the soil.

portions, form the food of all plants. Would you see how greatly the organic exceed the inorganic constituents of plants, take an oak,—the pride of England, her safeguard and defence, and cut down the noble tree; it will be found to contain several tons of wood. To ascertain what portions it has derived from the atmosphere, and what from the soil, set fire to it,—burn it up, and you will find, for every 100 lbs. weight, there will be about 3½ lbs. of ash left. That portion, consisting of the chemical compounds, is re-dissolved into the atmosphere, from which it was derived; and the other, the ash left, is what it has taken from the soil; the former being its organic, and the latter its inorganic constituents. Yet, insignificant as these inorganic constituents may appear, they are absolutely necessary to the full development of plants, and hence they form an important part of their food. We will therefore, before proceeding further, consider the nature of each of these respective substances. This is necessary, inasmuch as if one, even to all appearance the most unimportant, be absent, though all the rest, in their proper proportions, be present, it is impossible that the plant can be produced in perfection. As the organic so greatly exceed in proportion the inorganic constituents of plants, they demand our first attention; and one of the most important of these is—

CARBONIC ACID.

Carbonic acid is a chemical combination* of carbon and oxygen, and, though absolutely necessary to the

* It is essential to understand clearly the distinction between a *chemical combination* and a *mechanical mixture*. For a lucid explanation of this difference see Appendix A.

growth of plants, is in itself a narcotic poison, and, when inhaled, produces stupor, insensibility, and death. In the coal-mines of England, it generally goes by the name of *choke-damp*, and, owing to its being much heavier than common atmospheric air, it is frequently found at the bottom of old wells, brewers' vats, cellars, &c., and has frequently proved fatal to persons who have incautiously descended into such places. We find it in its most familiar form in the sparkling bubbles which arise on uncorking a bottle of soda-water, and in those which escape in the fermentation of beer. It is one of the products of respiration, the air which we breathe out of our lungs being strongly charged with carbonic acid. It is largely found when charcoal is burned; and this will explain the fatal effects arising from burning charcoal in a close room. Carbonic acid forms about one half the weight of common limestone, and is driven off by heat in the process of lime-burning; and so feeble is its union with alkalies, that any other acid, even vinegar, will drive it away and take its place. But my object is not so much to explain what carbonic acid is, as to point out its effect in promoting the growth of plants, and showing in what manner it is taken up and appropriated by them. In the first place, carbonic acid gas is the source from whence plants derive at least one half of their dry bulk. I have already stated that carbonic acid forms a large portion of the breath exhaled from the lungs in the process of respiration. In this particular the animal and vegetable economy is directly opposed, the former appropriating the oxygen in the atmosphere, the latter the carbon. Without going fully into this subject, it will be sufficient to state that the blood, in passing from the heart to the extremities, in its

course to solidification, becomes charged with noxious humours and other impurities; in this state it is returned by the veins to the lungs, where, meeting with the health-giving oxygen in the air inspired, the poisonous carbonic acid is expelled, and the blood, in a purified state, is again presented to the heart, and, by the contractile power of that organ, is again forced through the arteries in support of the animal structure.* In the case of plants, the action is different. Every bud, as well as every seed, contains the embryo of a future plant; and these, under the influence of heat and moisture, send forth shoots; in the latter case, the seed sends forth a rootlet, which takes a downward course; and also, at the same time, one or two seed-leaves are produced, which take an upward direction. The food necessary for sustaining these leaves may be said to have been already formed in the seed, while the rootlets themselves imbibe carbonic acid from the soil in a state of solution, at the same time that the seed-leaf is imbibing it from the atmosphere. The carbonic acid so imbibed assists in forming, if it does not altogether form, the stem. The stem again, in the course of its growth, puts forth other leaves, all of which are furnished with myriads of little mouths or suckers, which absorb more carbonic acid; while the roots, as they extend, also imbibe more of the same material in the water they suck up; and thus the plant progresses towards maturity. This carbonic acid imbibed by the roots and leaves, under the influence of heat and light becomes decomposed; during this decomposition, the oxygen is liberated, escapes through the

* All who wish to be further informed upon this interesting subject, are recommended to consult JOHNSTON'S *Life, Health, and Disease.*

numerous pores in the leaves, while the carbonic acid becomes solidified, and forms a part of the plant. Thus it will be seen that while animals inhale oxygen, which unites with a portion of the carbon in the blood, and keeps up the temperature necessary to health, it at the same time expels the poisonous carbonic acid gas contained in it, and thus renders it fit for the further building-up of the animal frame. On the other hand, plants inhale carbonic acid, which, under the influence of light and heat, becomes decomposed and solidified, and thus builds up the structure of the plant, while the oxygen is set free, and escapes through the pores and leaves.

I have already stated that carbonic acid is a chemical combination of carbon and oxygen; this latter gas may, with great propriety, be called "the sour-maker," seeing that no acid can be formed without its aid; while carbon is nothing more than pure charcoal; and the diamond, in fact, is nothing but pure charcoal in a crystallized state. To most of us carbon is more commonly known as "woody fibre," and, exclusive of water, forms about one half of the food consumed by both man and beast. Having now seen the use of carbonic acid in promoting vegetation, we will proceed to consider—

THE CONSTITUENTS OF WATER.

Common as water is to all of us, there is no fluid that differs more widely in its constituents, two samples being rarely found alike. Pure water is composed of two gases, oxygen and hydrogen, in a state of chemical combination; *i. e.*, supposing these two gases were collected

in their proper proportions* in a glass globe, they would mix, but not combine; but if a stream of electricity be brought to bear upon them, they mutually decompose and form water. Singular as it may appear, water, which is most effectual in extinguishing fire, is formed of two gases, one of them in the highest degree inflammable, and the other the most powerful supporter of combustion known. In agriculture, the most important property of water is the power it possesses of dissolving solid substances, which, but for its influence, would remain inert in the soil; but these substances, being dissolved by the agency of water, are presented to the roots of plants in the only form in which they can be absorbed; and thus, whatever fertilizing properties the soil may contain, are rendered available for the purposes of vegetation. Another important property possessed by water is the facility with which it rises in vapour and commingles with the atmosphere; but for this property, a great portion of our crops, particularly upon dry sandy soils, would be burnt up in very dry seasons. But, as if to compensate for this, the warmer the weather the greater is the amount of moisture contained in the atmosphere.† The atmosphere in this country is never

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* Eight pounds of oxygen combined with one pound of hydrogen, form nine pounds of water.

† The following table is extracted from SIBSON'S *Agricultural Chemistry*, a book which every farmer who is desirous of studying the science of farming cannot do better than consult.

Water in 100 parts of Air.	Parts of Water.
At 30 degrees of thermometer	·41
„ 50 „ „	·80
„ 80 „ „	2·01
„ 90 „ „	2·70
„ 100 „ „	3·60

so dry but plants can obtain moisture from it; and there are many substances of so deliquescent a nature as to absorb moisture from the driest atmosphere. Among these, potash, soda, salt, and other chemical compounds which afford food for plants, are of this character; and if we bear in mind that the whole of our root and green crops contain from 60 to 90 per cent. of their whole weight of water, the value of it, both in the soil and atmosphere, will be at once apparent. Another property of water is, that, being composed of oxygen and hydrogen, it yields these gases to the growing plant, and thus assists in forming numerous compounds which enter into their structure. For instance, hydrogen and nitrogen form ammonia; and so great is the affinity of water for ammoniacal gas, that it will absorb from six to seven hundred times its bulk of that valuable stimulant to vegetation; and, but for this affinity, the nitrogen contained in the atmosphere would, so far as vegetation is concerned, remain perfectly useless. Another very valuable property of water is, that, like other bodies, it expands by heat and contracts by cold; but, unlike other bodies, after it has been cooled to a certain point (40°), it again expands. While freezing, water expands very much, bursting the strongest vessels in which it may be contained; and it is in this way that the hardest rocks are gradually crumbled down into soil fit for vegetable life; and it is in this way, also, that it acts in crumbling down stiff clay soils: the moisture, which has penetrated into the smallest crevices during summer, freezes during winter, and, by its expansive force, breaks up the solid mass. Hence is it that strong clays are so much benefitted by being left rough-ploughed to the action of the frost; and hence is it that wheat is so often

thrown out of the soil. Water is 815 times heavier than air; a cubic foot of water, at the temperature of 60°, weighs 1,000 oz. (avoirdupois); or, in other words, since a gallon of water weighs 10 lbs.,—

"A pint of pure water
Weighs a pound and a quarter."

AMMONIA, AND ITS PROPERTIES.

Ammonia is formed by the chemical combination of the two gases hydrogen and nitrogen, *i.e.*, 14 lbs. of nitrogen and 3 lbs. of hydrogen make 17 lbs. of ammonia. It exists in considerable quantities in fermenting dung, and has been detected in minute proportions in rain-water;* but the most prolific source from which ammonia is obtained at the present time, is from the distillation of coal in the manufacture of gas; and it is from this source, almost wholly, that most of the salts of ammonia met with in commerce are now obtained. This subject will be noticed at length under the head of "Gas-refuse." The following are the constituents of the chief salts of ammonia:—

	Acid.	Ammonia.	Water.	
Sulphate	54·66	14·24	31·10	parts
Carbonate	45·00	43·00	12·00	in
Muriate	49·55	31·95	18·50	100.

* Liebig has asserted that every pint of rain-water contains one quarter of a grain of ammonia; but until I have corroborative evidence of this fact, I must take leave to doubt its accuracy, seeing that the latest experiments of Boussingault go to show that the largest quantity of ammonia present in rain-water is only 1 grain to 33 gallons; and even in pump-water, contaminated by animal impurities, not more than 1 grain to 2 gallons could be detected, which is only one-sixteenth part of a grain to the pint. Another of Boussingault's experiments gives 1 grain to every 5 gallons of rain-water; and this is corrobo-

As the offices of ammonia in promoting vegetation are in the highest degree important (as will presently be seen); and as it is, even in the cheapest of its salts, an expensive article to purchase, it is most essential to the interest of every farmer to know how he may obtain the greatest amount of it from his own farm-stead. Valuable as this commodity is, there is nothing which is more recklessly wasted. It is wasted in our stables, pig-sties, cowsheds, and crew-yards; in our ditches, drains, and dungheaps; in short, it may be said to be wasted almost on every hand, simply because a great majority of our farmers are either too ignorant, too prejudiced, too apathetic, or too indolent to adopt the very simple means requisite to preserve it.

Who, we may ask, has not had his sense of smell affected, and felt his eyes water, on entering a stable in a morning, after it has been closely shut up all night? That pungent smell arises solely from the carbonate of ammonia escaping from the urine voided by the horses during the night, every 1,000 lbs. of which contain 16 lbs. of pure ammonia, or 1¾ lb. more than is contained in 1 cwt. of sulphate of ammonia, worth from 15*s.* to 16*s.* Now see by what a simple and inexpensive contrivance this might all be saved: 1 cwt. of sulphate of iron (common green copperas), which can be bought for about 5*s.* (the wholesale price being only 4*s.*), is sufficient to mix with 100 gallons of water, and this, when thoroughly dissolved, is sufficient to moisten from three to four cartloads of sawdust. All that is then required, is to sprinkle the preparation

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rated by M. Marten in the *Ann. de Chimie*, 1856. But, from the great discrepancies existing among the statements of various authors on this subject, but little dependence can be placed on any of them.

freely (say one-eighth of an inch thick) upon the floors of the stable or cowshed, and not only will the ammonia, which would otherwise escape, be absorbed, but the whole of the buildings will be sweetened, and the cattle preserved from many disorders,—lung diseases and blindness among the number. What is true of stables and cowhouses, applies equally to pigsties, crew-yards, and dungheaps; from all of which the escape of ammonia is immense. The ammonia contained in urine as voided by cattle, being chiefly in the form of a highly volatile gas (carbonate of ammonia), the effect of the sawdust moistened as before mentioned, is to attract it, and convert it into sulphate of ammonia, a non-volatile salt. Nor does the advantage of this process rest here; it gives to the farmer an extra quantity of most valuable manure, which, on mixing, renders that in the crew-yard and dungheap more valuable still, by assisting the process of fermentation and fixing a number of poisonous gases, alike offensive to the sense of smell and injurious to health.

It is a lamentable fact, but it is no less true, that even at the present day a very large proportion of our farmers have an affectionate prejudice in favour of a stink; they really fancy that the more manure stinks, the stronger it must be; when the very reverse is the fact. The stench arising from manure is generally attributable to one of two causes, or, more frequently, to both at the same time; viz., the escape of either carbonate of ammonia, or of sulphuretted hydrogen, both valuable for their fertilizing properties, and both of them injurious and even poisonous to animal health and life: for the blood must inevitably be vitiated by the frequent inhalation of noxious gases.

It is certainly difficult to put down the pecuniary cost of a stink; but if a farmer will take the value of one-half of the food, the loss of his cattle, the amount of his farrier's bill, and to these add the cost of "medicine and attendance," rendered necessary by the sickness of himself, his wife, and his family, and divide the gross amount by two, after adding about 25 per cent. for loss of time and labour, he will arrive at something like the cost of this most expensive but fondly-cherished fallacy. So far as his loss by the escape of ammonia is concerned, he may be enabled to form some notion of it by the following simple experiment. Let him purchase an ounce of carbonate of ammonia, which he may do of any druggist for about 2*d*., and place it upon a plate before his fire: if it be pure, it will all evaporate in ten or fifteen minutes. Now this carbonate of ammonia upon the plate is identical with the chief part of that produced in his dungheap by fermentation, as well as that in the urine voided by his cattle.

As I shall have occasion to notice this subject in a future chapter, we will now proceed to consider the functions of ammonia, not only in promoting the growth of plants, but in adding to their value when grown.

Plants take up their ammonia precisely in the same way that they absorb carbonic acid and water, *i.e.* partly through their roots, and partly through their leaves; but by far the greater portion of ammonia found in plants is taken up by their roots. That some portion of it is taken up by their leaves, we have abundant proof; seeing that if a little carbonate of ammonia (common smelling salts) be put into a saucer and placed near growing plants, they speedily assume a greener and

more healthy appearance.* But the quantity of ammonia taken from the atmosphere is far from being sufficient for the full development of cultivated plants, and as many of them are grown upon poor thin soil, containing little or no decayed vegetable matter, it is necessary that it should be supplied to the plant in the form of manure; and as ammonia is an essential constituent in guano, soot, nitrate of soda, and other artificial manures, this will account for their beneficial effect when applied as a top-dressing. But, it may be asked, how it occurs that, with the great abundance of nitrogen contained in the air, plants cannot receive a sufficient supply of it from that source, seeing that the atmosphere is composed of 79 parts of nitrogen mixed (not combined) with 21 parts of oxygen, and that this nitrogen is the basis of ammonia? True, and at first sight it would appear that there was a greater danger of plants being drowned than starved in it: this, however, is not so. The grain crops we cultivate (and, as we shall see presently, it is by them that the greatest amount of ammonia is required) cannot, of themselves, extract a single particle of nitrogen from the atmosphere for their own immediate use.

Boussingault informs us that this privilege is enjoyed only by a very few of our cultivated plants; such as clover, pease, beans, and probably mangolds, turnips, and potatoes. But, as before observed, our grain crops must receive their ammonia from the soil, or

* Some plants, particularly those of the balsamic class, are peculiarly susceptible to the influence of ammonia. Some time since, having accidentally spilt some acid upon a new coat, I proceeded to neutralize its effects by the application of caustic ammonia. I incautiously placed the sponge I used too near a favourite balsam, and left it there. On my return, an hour after, I found the balsam was dead.

not at all; and it is, therefore, absolutely necessary that the soil intended for the growth of these crops should be strongly charged with this important fertilizing ingredient; I say *strongly charged*, inasmuch as experience has proved that it is not sufficient to put even double the quantity of ammonia into the soil which the plant is found to yield on analysis. That this doctrine is shared by Mr. Lawes, we find from a statement made by him some years ago, wherein he states it as his opinion: "That every bushel of wheat, containing in itself about 1 lb. of nitrogen, requires 5 lbs. of ammonia for its production, instead of 1¼ lb., which would be equal to 1 lb. of nitrogen." From this it is clearly manifest that the wheat crop not only appropriates but absolutely *wastes* a large portion of ammonia during its growth. This I am not able to account for; but, as before observed, experience has proved it to be the case; and this fact, at all events, fully accounts for the exhaustive effect on the soil produced by wheat crops. "The gross weight of vegetable produce," says Mr. Acland, "raised on an acre of good land, managed on the 'four-course' system, will be, in the course of four years, about 40 tons, in round numbers, of which about four-fifths will be water; leaving in round numbers about 19,000 lbs., or say, 8 tons of organic matter, and about 1,300 lbs. of inorganic matter, or ashes, which would be left, if all the crops of the four seasons were burnt." . . . "The organic matter,—that which is capable of being burnt away, of which carbon and nitrogen are the two principal parts, as they were united with the elements of water in carbonic acid and ammonia" (and in those forms imbibed by the plant)—"the four years' crop will be found to contain about 9,000 lbs. of carbon, and about 3 cwt. of

nitrogen. The carbon is about equally divided between the corn crops and the green crops, but the nitrogen is divided in proportion of 1 cwt. to the corn crops and 2 cwt. to the roots and grass."—*Meat, Milk, and Wheat*, p. 34.*

How Ammonia adds to the value of Plants.—The value of all plants cultivated for the food of man depends upon the amount of nourishment they contain, and the power they possess of building up and sustaining the animal structure. For this purpose two important agencies are required; viz., flesh-forming and fat-forming properties; the former being termed by chemists "the elements of nutrition," and the latter "the elements of respiration." Though immaterial to our purpose, it may be useful to know the various names of these flesh-forming constituents separately, although, by whatever name they may be called, they are one and all precisely the same, whether they appear as albumen, gluten, caseine, vegetable fibrine, or legumine.

Albumen occurs nearly pure in the white of an egg; it is also largely found in the blood, the humours of the eye, the flesh of animals, and in oily seeds. It coagulates when mixed with most acids, and many metallic salts. Hence white of egg is given in cases of poisoning with copperas or arsenic.

Fibrine is found soluble in the living blood, but after death, or separation from the living body, it spontaneously coagulates into fibres which are insoluble in water. It also occurs in lean flesh or muscular fibre, from which it derives its name.

Gluten, or Vegetable Fibrine, is tasteless and odour-

* This treatise of Mr. Acland's every farmer ought to possess.

less, hardens on drying into a horn-like mass; it is a tough, adhesive, glue-like substance: hence its name.

Caseine is the curd of milk, and derives its name from the Latin *caseus*, cheese, of which substance it is the chief constituent.

Legumine is found in most plants, but chiefly in pease, beans, and other seeds of a similar kind.

The whole of these, as I have before observed, are all nitrogenous or flesh-forming constituents.

"If," observes Professor Playfair, in one of his lectures, "water be poured on fine flour, in a sieve, and stirred about, a milky fluid will percolate into the basin below; on adding more water, the liquid will, after a time, pass through quite clear; on the sieve will be seen a glue-like substance, called *gluten*, while at the bottom of the basin will be found white granulated particles, called starch. . . Chemists," continues the learned professor, "were surprised to discover that this body never varies in its composition. It is the same in corn, beans, or from whatever plant it is extracted, and, still more strange, though in outward appearance they seem to differ so much, this gluten we have on the sieve is one and the same thing as the muscle of my arm, as dried blood, or the flesh of the ox: so we eat the flesh ready formed in our food. This is a very wise arrangement of nature. The vitality of plants is not required to execute the commands of the will, and therefore its whole powers are employed in creating new compounds; but in animals the vital principle has many duties to perform, assigned to it by the will: the powers are therefore husbanded to this end. All that the vitality in the animal economy has to perform, connected with nutrition, is to assign a place and form to the food, which is already

of the proper composition." The bearing of this upon what I have before advanced will at once be perceived, when we remember that the two substances just mentioned, viz., the gluten on the sieve and the starch at the bottom of the basin, perform two totally different functions in our bodies. In their chemical composition they also differ; seeing that the *gluten* contains carbon and oxygen, with *nitrogen*, while the *starch* contains carbon and oxygen, *but not one particle of nitrogen*. Therefore, it is to the presence of nitrogen that every description of food owes its flesh-forming properties. And further, as plants have no power of absorbing nitrogen, *per se*, but only in the shape of ammonia, it becomes clear that not only do plants require ammonia to stimulate their growth, but that its presence adds to their value when grown.

To illustrate this fact more clearly, and in order to show the extent to which it is capable of improving the quality of wheat crops, it will be sufficient to quote the following experiments:—One hundred parts of wheat grown without manure, yielded gluten to the extent of 9·2 per cent., and starch 67·7 per cent.; but from 100 parts of the same variety of wheat manured with animal urine, were obtained as much as 35·1 per cent. of gluten, and but 39·3 per cent. of starch; that is to say, the manure had given to the wheat four times as much of the nutritious element, and, as food for man, had consequently rendered it four times more valuable.—(JOHNSTON'S *Lectures*, p. 103.) The same argument applies equally to grass and fodder crops: the richer these are in nitrogen, the more beneficial their effects. A cow, for instance, fed upon highly-nitrogenized food, will give a larger amount of milk, and of better quality for pro-

ducing cheese and butter, than one badly fed; and it is a well-ascertained fact that two horses fed upon highly-nutritious food will perform a greater amount of labour than three kept upon food deficient of nitrogen: this important question will be more fully treated in that part of our work devoted to cattle-feeding.

WHAT PLANTS DERIVE FROM CARBON.

Having now noticed the flesh-forming constituents of plants, let us proceed a step further, and consider their fat-forming constituents, which may be said to consist of starch, gum, sugar, woody fibre or lignine, fats, oils, and resins. They all consist of carbon and the elements of water.

Starch is abundantly found in all plants, and is obtained from their seeds or fruit, as wheat-starch or rice-starch; from their roots or underground stems, as potato-starch, tapioca, and arrowroot; and from the pith of certain trees, as sago, &c.

Gum is the natural exudation of certain trees; but a similar substance, called "dextrine," may be formed from starch by the action of sulphuric acid; and many of our ordinary gums are now being replaced by this material.

Sugar is the name for any sweet substance, whether derived from plants or animals. *Cane*, or *ordinary sugar*, is produced from the sugar-cane, beet-root, sugar-maple, &c.; *grape-sugar* is the sugar of fruits, and is also prepared from honey and starch; *milk-sugar* is obtained from evaporating and crystallizing *whey; glycerine* is obtained from oil, and differs from the preceding in not yielding alcohol on fermentation.

Lignine, or woody fibre, forms the structure of plants, and is found in nearly a pure state in fine linen and cotton.

The whole of the foregoing being destitute of nitrogen, as before observed, are not possessed, properly speaking, of nourishing properties, and are therefore called "the elements of respiration." They supply animal bodies with heat: the carbon they contain, meeting and uniting with oxygen in the process of respiration, combustion results; thus, they may be said to be literally burnt in our bodies; and by this means animal heat is sustained. In this respect these fat-forming properties of plants are not only useful but necessary in building up and perfecting the animal structure, and keeping the flesh formed by the nitrogenous portion of the food taken, in that state of temperature best fitted for supporting the greatest amount of strength and endurance; and when more of this non-nitrogenous food is taken than is required for this purpose, it is converted into fat. This part of the subject also will be more fully dealt with when we come to dscuss the question of cattle-feeding.

Having now seen of what the *organic constituents* of plants are composed, and their uses, we will next proceed to notice another class of substances necessary for the food of plants; viz., their mineral, or—

Inorganic Constituents.—The organic constituents of plants, it will be remembered, were stated to be composed of oxygen, hydrogen, carbon, and nitrogen: these are combustible, and will burn away in the air, leaving nothing behind. The inorganic constituents are the reverse of all this, inasmuch as the inorganic portion of plants consists of mineral substances only, which will

not burn away, but which form the residue or ash left after the organic portion is consumed. These are chiefly composed of potash, soda, lime, magnesia, phosphoric acid, &c.; and although these form but a very minute portion of the whole bulk, they are equally important, seeing that no plant can be built up without them.

It would be a waste of both time and space, so far as practical farming is concerned, to enter into an elaborate description of the whole of these inorganic constituents; I shall therefore confine my observations to such of them as have been found to be of the greatest importance in manures, by reason of their frequent scarcity in cultivated soils. And these may be said to consist of phosphate of lime, potash, and common salt, the remainder being generally found sufficiently abundant in all soils of average fertilizing quality; and even salt is often found in abundance, particularly in soils not far distant from the sea. But, before proceeding further, let us see how it is ascertained that these substances—viz. phosphoric acid, potash, and salt—are really present in plants. If for this purpose we take a stem of wheat, a swede, or mangold, and weigh out 100 grains, then put it into a common metal ladle upon a hot fire, and let it remain there till everything combustible is burnt away, we shall find a small quantity of ash left behind. Until very recently, chemists took but little notice of this ash, seeing that, in ordinary cases, it did not weigh more than 2¼ per cent. of the whole bulk. But recent investigations, and particularly those of Liebig, Lawes, and Gilbert, have proved that this ash is in the highest degree essential; and how it is essential we shall presently show. Now this ash came from the soil alone, and, being incombustible, cannot, like its more volatile com-

panions, fly away in smoke, gas, or vapour; but, upon being examined and subjected to the test of certain chemical re-agents, it has been found to consist of the several mineral substances before named, and without which it is impossible for plants to arrive at perfection.

Without phosphoric acid, a plant could not produce seed, inasmuch as that acid enters largely into the composition of all seeds; and without it, the grain of wheat would possess no skin, as phosphoric acid is a necessary constituent of bran, which contains a very considerable proportion of it. In short, there is no plant cultivated for the food of man in which phosphoric acid is not an important constituent; while potash, lime, salt, &c. &c., all enter to a greater or less extent into the structure of both plants and animals. We may add, too, that without phosphoric acid a man could have no bones, as phosphoric acid, combined with lime, forms the principal bulk of bone, and constitutes what is generally known as bone-earth. The following table will serve to show the respective amounts of the more important of the inorganic compounds, or fixed ingredients in the various crops therein named. It would have been an easy matter to extend the table, but that here given will, no doubt, be found sufficient for all practical purposes:—

WEIGHT OF FIXED OR INCOMBUSTIBLE INGREDIENTS IN POUNDS AVOIRDUPOIS IN EVERY TON OF THE FOLLOWING CROPS.*

CROPS.	Potash.		Soda.		Lime.		Magnesia.		Phosphoric Acid.		Sulphuric Acid.		Salt.		Sand.	
	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.
Wheat grain	5	0½	5	6	2	3	1	9	8	15¾	1	0¼	0	3¼	2	4
,, straw	0	7¼	0	11	5	6	0	11½	3	14	0	11½	0	1	64	4
Barley grain	6	3¼	6	8	2	7½	4	0¾	4	12	1	15	0	4¼	26	7
,, straw	4	0½	1	1	11	15¾	1	11¾	2	4	2	8½	1	9½	76	4
Oats grain	3	5¾	2	15¾	0	13	1	8	1	9	1	8¼	0	4½	44	5
,, straw	19	7	Trace.		3	6¼	0	7	0	4½	0	8½	0	2¼	102	12
Swedes	39	4½	26	2¾	18	11	6	5	9	2½	20	0	157	13¼	10	9½
Turnips	1	11	2	7	2	13	0	4¾	1	9	0	14¾	12	7	0	13¼
Mangolds	33	2¾	71	3	6	6	2	15½	3	12	2	12	134	4	2	6
Potatoes	8	9	5	4	0	11¾	0	11½	0	15¼	1	3½	0	5½	0	3¼
Carrots	60	14	15	14	11	5	6	8¼	8	13½	4	10½	1	0¼	2	6¼
Cabbage..........	41	6	13	0	40	12½	4	8¼	9	12¼	17	7¾	11	9¾	11	13
Beans grain	9	4¾	18	4½	3	11¼	3	8½	6	8½	2	0	0	14¾	2	14
,, straw	37	1¼	1	2	13	15¾	4	10	5	10	0	12¼	1	13	4	15
Pease grain	18	2¼	16	8¾	1	4½	3	0¼	4	4	1	3	0	13¼	9	2½
,, straw........	5	4	—		61	2	7	10½	5	6	7	8¾	Trace.		22	3¼
Red clover........	9	6	2	7¾	1	9	1	8½	3	0¼	2	1½	1	11½	1	11¾

* To avoid the use of decimal fractions, I have thought it advisable to insert the weights in pounds avoirdupois; and though not strictly accurate, they are sufficiently so for ordinary purposes.

A mere superficial glance at the preceding table will be sufficient to show its bearing upon the subject under consideration, and will enable the practical farmer, by a judicious application of special artificial fertilizers, to return to the soil those substances which former crops may have removed in any remarkable degree from it, or to re-supply them, by mixing with his ordinary manure when preparing his land for following crops. By way of illustration, let us suppose a farmer to be preparing his soil to receive a crop of swedes; he will find that, to produce a good average crop (25 tons per acre, for instance), he will require an extra amount of salt, seeing that 25 tons of swedes will require at least 35 cwt. 1 qr. of that material alone; and, as the crop could not be expected to take up all the salt applied, a dressing of 2 tons per acre would not be an overdose;* because, if not present in sufficient quantity, it would be utterly impossible to secure a full crop. And so on, with every other description of produce; care should be always taken to supply the soil with a sufficient quantity of the ingredients it contains in its composition. Nor is this all a farmer requires to know upon this subject: he ought to know not only what his soil already contains, but also what ingredients the manure contains which he is about to apply, independently of special fertilizers. To assist him in this matter as far as may be, the following table has been appended, which cannot but prove useful, as it has an immediate bearing upon the one preceding it:—

* This is supposing the soil to be entirely destitute of salt.

CHEMICAL CONSTITUENTS IN POUNDS AVOIRDUPOIS CONTAINED IN ONE TON OF THE FOLLOWING MANURES.

MANURES.	Chlorine.		Sulphuric Acid.		Phosphoric Acid.		Soda.		Magnesia.		Potash.		Ammonia.	
	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.
Farmyard dung	1	9	1	4	5	1	1	10	18	8	2	4	13	5¾
Night-soil	3	0	2	8	120	0	4	10	2	7	6	7	47	15¼
Fresh bones	—		—		580	0	—		—		—		145	5
Dry blood	—		—		—		—		—		—		444	3
Peruvian guano	62	0	93	8	283	9	36	15	—		66	8	221	9¼
Soot	22	9½	194	3¼	5	12¾	2	11¾	8	11¼	7	1¼	50	2
Common Salt	1,344	0	—		—		833	0	—		—		—	
Gypsum...............	—		1,317	0	—		—		—		—		—	
Mixed urine, per 100 gals.	1	6	3	8	2	6	5	9	—		2	0	18	3¼
Gas-liquor do.	—		—		—		—		—		—		17	11¼
Nitrate of soda..........	—		—		—		8	3	—		—		364	0
Sulphate of ammonia	—		1,357	0	—		—		—		—		470	0

With these tables before him, the farmer may easily ascertain the amount of any particular ingredient removed from the soil by any particular crop, by a reference to the former, as well as the amount of any particular manure that is required to restore the balance, by referring to the latter.

The influence of different manures upon the chemical composition of the plant is much more considerable than farmers commonly believe. The following results, obtained by Hermstadt, from a series of experiments tried upon wheat, will be sufficient to demonstrate this fact. He sowed equal quantities of wheat upon the same ground, and manured them with equal weights of the different manures set forth below; from 100 parts of each sample of grain produced, he obtained starch and gluten in the following proportions (JOHNSTON'S *Lectures*, p. 103):—

	Gluten.	Starch.	Produce.
Soil simple	9·2	66·7	3-fold.
Manured with potato haulm	9·6	65·94	5 ,,
,, ,, cow-dung..........	12·0	62·3	7 ,,
,, ,, pigeon-dung	12·2	63·2	9 ,,
,, ,, horse-dung	13·7	61·64	10 ,,
,, ,, goat-dung	32·9	42·4	12 ,,
,, ,, sheep-dung	32·9	42·8	12 ,,
,, ,, dried night-soil	33·14	41·44	14 ,,
,, ,, dried ox-blood......	34·24	41·43	14 ,,
,, ,, dried human urine ..	31·1	39·3	12 ,,

An examination of the foregoing table naturally leads to the conclusion that both dried ox-blood and dried night-soil form the best manure for wheat crops; but it is by no means to be inferred that a continual repetition of these manures would always succeed in producing good crops of wheat. I do not believe in specific manures

producing continuously a succession of the same or any other kind of crop. In my opinion, *the soil requires a change of manures equally with a change of crops.* I do not believe there is any manure that will bear constant repetition, other than that originally provided by Nature: *i.e.* decayed vegetable matter, or, what is essentially the same, well-fermented farmyard dung. That certain mineral compounds will act beneficially in restoring the balance of nature, when disturbed by the extraction of a large portion of any fixed ingredient, I do not doubt for a moment; but I also believe that a continued repetition of these compounds would be worse than useless: they would be mischievous. To supply phosphoric acid, potash, or ammonia, where already abundant, would be nearly as absurd as to attempt to make a drunken man sober by giving him an extra dose of brandy-and-water; and therefore I am clearly of opinion, that all that science can do is not to supersede Nature, but to assist her in maintaining that equilibrium which it is the tendency of the production of such crops as are not consumed on the land to disturb.

The great cause of failure in the application of special fertilizers does not rest so much in the article itself as in the injudicious application of it. A soil possessing any one ingredient in excess is quite as likely, nay, more likely, to be unproductive, than if such ingredient were absent altogether. The rotation system of cropping, as now generally practised, has doubtlessly led to this theory of specific nourishment; and in support of it, numerous arguments have been put forward. Among the number, it has been urged, that if all plants required the same food, the soil would be equally liable to exhaustion by a succession of different crops as by a

repetition of the same crop. This argument, at the first blush, appears somewhat startling; but it must be borne in mind, that plants of different kinds, growing on the same spot, rob or starve each other, which could not be the case if every different plant drew from the soil a different kind of nourishment. Without pushing this argument further, I shall content myself by re-asserting what I have before advanced; viz., that I do not believe there is any specific manure for plants apart from that of farmyard dung,—*i. e.*, no manure that could possibly supersede it, even though it could be manufactured at half the cost. This manure never fails on its own account, though it is more or less valuable, accordingly as the cattle by which it is made have been well or ill fed. The stomach of the animal is Nature's own laboratory, and chemical changes are there effected in a manner far superior to those produced by human ingenuity. The application of farmyard dung alone will bear constant repetition,—the land never tires, never grows sick of it. Formed by the acid fermentation of vegetable matter of almost every description, it is by such process converted into one homogeneous substance, suitable for every soil, and fitted for the nourishment of every known plant. Were it otherwise, Nature would have proved herself a bungler, and vegetation would, if not altogether, at least partially, have ceased to exist. I will only make one more observation, before limited space compels me to close this part of my subject. Look at the vast forests and prairies of America, extending over thousands of miles, where neither spade, plough, nor axe has ever yet penetrated. They have lived, flourished, decayed, died, and rotted through countless ages, and yet they

suffer no diminution, either in point of size, variety, or species. What but a natural nourishment common to all plants could have sustained them?

CHAPTER III.

MANURES.

Prior to the days of our illustrious countryman Sir Humphrey Davy, agriculture was simply a time-honoured, but crude practice; and to him is the honour due of being the first to elevate it to the rank of a science. Since the benefits conferred by his discoveries, much has been done by other men of eminence to improve the practice of farming, and to explain its rationale. To the bishop of Llandaff, Lord Kaimes, Mr. Curwen, and other men of deep learning and scientific research, are we indebted for the rapid strides made in the progress of agriculture, and to the increased estimation and importance in which it is now held, notwithstanding the vast development of our commerce and manufactures; and the time is fast approaching when the whole country will probably concur in recognizing agriculture as the real foundation of its strength, as well as a primary agent in promoting the welfare and happiness of the people. The last twenty years have done much to promote the application of science to farming; and the

favourable spirit with which improvements thus originated have been generally received, has had the happy effect of greatly increasing our national prosperity. But it is to the influence of Liebig's "Agricultural Chemistry," which first appeared in 1840, that we may attribute the complete revolution which has taken place in agricultural operations. The effect produced by Baron Liebig's book has been well described by Mr. Thompson (*Agric. Jour.*, No. 36):—

"In the year 1840, Baron Liebig first published in this country his great work on agricultural chemistry. At that time a very general impression prevailed that British agriculture was capable of very great development, but that there were no established principles to guide its advance, nor even any sure ground on which to tread, if any deviation were made either to the right or to the left of the beaten track marked out by our forefathers.

"The appearance of Baron Liebig's book was therefore naturally and deservedly hailed with great delight. All admired the masterly way in which he traced the elements of vegetable life to their original sources, pointed out their chemical composition, and followed them through the various stages of the plant's development and maturity until the process of decay had again reduced them to the elementary form. His main position, too, that in order permanently to maintain the fertility of cultivated land it was necessary to restore to it all the substances contained in the various crops exported from the farm, was as new to agriculturists as it was convincing, and its application to practical agriculture seemed as simple and easy as it has since been found to be complicated and difficult.

"For the time, however, the whole secrets of the science of agriculture appeared to be laid open by the production of the master key; nor could it well be otherwise. The accuracy of the chemical investigations which formed the basis of this work has never been questioned; and the reasoning with which the various results were united into one consistent and comprehensive scheme seemed so sound and satisfactory, that the delighted reader was led on by easy steps till he reached an elevation from which it was difficult to avoid believing that the prospect before him included the whole of the *past*, *present*, and *future* of agriculture."

Had Liebig contented himself with the publication of his brilliant theorems, it might have been better for his fame: farmers would have gradually applied his principles to practice in the field, and, experience proving them to be correct, the belief in their usefulness would have extended; the theory of one day would have been considered a fact the next, the day after a doctrine, and at length would have become a truism so trite as to cause wonder that an axiom so plain should ever have been doubted. Science and practice would then have gone hand in hand, the former pointing out the way, and the latter pursuing it. In this way the farmer would have become more intelligent, and farming operations more intelligible. But this appears to have been regarded as too slow a progress for the illustrious German; he became impatient to have his principles generally and at once adopted, forgetting that the prejudices and practices of centuries were not to be eradicated and superseded by a *coup de main*. He made a tour through the agricultural districts of England and Scotland, in order to see for himself how our farming

operations were conducted, and what they required to bring them to that degree of perfection which he considered his theory could not fail to attain. The result of his journeyings was a new edition of his book, "revised and corrected," in which some very sensible observations were expunged, and some very questionable advice inserted; as though a single tour of a few months was of itself sufficient to enable any man, however intelligent, to correct practices based upon the experience of generations. This mistake, in all probability, led to another of a more damaging character. The baron, somehow or other, allowed his name to be mixed up with the manufacture of a new patent manure, which turned out a failure. This latter proceeding is much to be regretted, seeing that it not only placed him in a false position, but also placed his theory in antagonism with practice. Not that his theory was wrong, but that the application of it to practice was not right. Nor is this an uncommon occurrence: inventors themselves rarely succeed in the practical application of their inventions. I very much doubt whether Archimedes could have tapped a common screw-nut; neither do I think that even Watt himself would have made a very efficient driver of a common locomotive; while, as ladies well know, poets who write so rapturously on love, proverbially make the stupidest of husbands. Yet such is the idiosyncrasy of man, that the great majority are convinced they can drive a gig, edit a newspaper, or farm a small property better than any one else.

It is, therefore, not to be wondered at that Professor Liebig, after enunciating a theory, should consider himself better capable of reducing that theory to practice than any one else. But the failure of his manure, when applied

according to his own directions, proved one of two things; viz., either that the manure itself was valueless, or that it was not properly applied. Mr. Lawes, in one of his experiments, proves the latter to have been the case. The doctrine laid down by Liebig was, that it was only necessary to return to the soil the *mineral* constituents abstracted by the crops taken from it, and that the ammonia requisite to their growth was supplied in sufficient quantity from the atmosphere, in addition to that which the soil naturally attracted and retained till taken up by growing plants. In conformity with this theory, he brought out, as before observed, a patent *mineral* manure, which, when applied alone, proved to be useless. But Mr. Lawes, in the course of his experiments, had found out that mineral manures would not increase the yield of wheat, *without the addition of ammonia.* He first applied Liebig's manure alone, and the results yielded were quite insignificant; but when it was applied with the addition of ammonia, an increase of fourteen bushels of wheat and half a ton of straw per acre was obtained.

Hence it is evident, that however valuable mineral manures (super-phosphate for instance) may be, their effects are abundantly increased by mixing them with salts of ammonia, which, in addition to its own direct action in promoting vegetation, greatly assists in decomposing such vegetable substances as the soil may contain, thereby fitting them for the food of plants; and hence, also, its value when added to farmyard manure.

THE CHEMISTRY OF THE DUNGHILL.

This, of all others, is the most important branch of agricultural chemistry, and yet our dung-heaps are the opprobrium of British farming. A farmstead contains sheds and hovels for everything but the muck-heap; yet it is to his muck-heap that the farmer must look for both his cattle and his crops; and one would think that self-interest alone would be sufficient to induce him to strain every nerve to increase both the quantity and quality of an article of such paramount importance.

Before proceeding to notice the locality and formation best adapted for dunghills, a few remarks may be useful as to the difference in quality of animal excrements.

The dung of animals that chew the cud becomes, by that process, more thoroughly decomposed than that of others, and may therefore be mixed with the soil at once, without being collected into a dunghill. A horse does not chew the cud, and in horse-dung may be perceived seeds, particles of straw, hay, and other substances, broken into small pieces, but still not dissolved; it is therefore necessary that this process should be perfected in the dunghill. This difference between the dung of the horse and that of the cow is plainly visible in every pasture where they have been grazed; the grass round the former being withered and apparently scorched, while, round the latter, it is both more exuberant and verdant than the rest of the field. In collecting manure for a dung-heap, care should also be taken that dry and moist materials should be spread upon it in alternate layers, as, by the former extracting moisture from the other, they all become equally moist. Nor is the construction of

the dung-heap to be neglected. First, as to foundation: if the soil upon which it is to be built be in any great degree porous, it should be paved or concreted, to prevent the juices from sinking into the ground; and, to prevent those juices from being washed away, it should be sunk a few inches below the surface of the ground; it should also, to prevent the rain from running into it, be surrounded by a ring of clay or sods; and if the moisture happens to be superabundant, it should be led off by a small gutter, in order to impregnate the collected ditch-scourings—accumulations of twitch-grass or other weeds—with even rich mould too, laid down to receive it, which will make such accumulations equal to very good dung, and better than much of that which is collected in the ordinary way. I have often witnessed, with feelings of pity bordering upon contempt, a farmer sending his carts to market for artificial manures, when the roots of his hedges fronting the highways, and the adjacent ditches, were full of weeds and vegetable matter, which, if collected and putrefied, would have furnished him with manure amply sufficient for his wants. And here the half-starved system of farming again peeps out. To cut and collect these weeds, to scour ditches and hedgerows, would require the expenditure of a few pounds in extra labour; and, to save this, the farmer is content, nay, compelled, to spend double the sum in artificial fertilizers, the benefits derived from which are trifling beyond the first year, while good farmyard dung shows its beneficial effects for a period of four or five years.

Erection of Dunghills.—In erecting a dunghill, no matter whether large or small, care should be taken not to trample or press it down, as this has a tendency to exclude the air, and thus to prevent putrefaction: its own

weight will give it sufficient compactness to insure putrefaction being carried on; and, to prevent evaporation, it ought to be covered with a thin layer of mould. The neglect of this practice of covering over dung-heaps is, I am sorry to say, very general, and is about one of the most profligate ways of wasting valuable manure that can possibly be conceived. Not only is the dung-heap deteriorated in quality, but it is diminished in quantity, and that, too, to such an extent as would probably cause great astonishment to many of my readers; and I really hope that such of them as neglect the practice will no longer pursue a course by which, under the most favourable circumstances, they must sustain a loss of at least 25 per cent. From a series of experiments made by Koerte,* the loss of weight sustained by the exposure of one hundred loads of manure to the action of the sun, wind, and rain, was found to be as follows. One hundred loads at the end of the periods stated,—

In 81 days	it was reduced to	73·3 loads;	loss	26·7	loads.
254 „	„	64·4 „	„	35·6	„
384 „	„	62·5 „	„	37·5	„
493 „	„	47·2 „	„	52·8	„

This table only shows the loss in weight; the loss in quality would doubtless be in similar proportion; and if this statement be not sufficient to induce every farmer to protect his dung-heap from injury by wind, sun, and rain, nothing that I can add will be likely to do so.

"The value of farmyard dung," says Mr. Acland, "probably consists in several points. 1. That it presents a great choice of salts of all sorts, in every state

* GIRARDIN, *Des Fumiers considérés comme Engrais*, chap. v.: Paris.

of combination, and in every digestible form; so that the plant finds all its wants easily supplied. Well-made dung is always rich in ammonia, phosphates, and potash, which, as we have seen, are elements of prime necessity. 2. It acts mechanically on the soil, by loosening clay and binding light soils. 3. Its slow fermentation no doubt raises the temperature of the soil: and lastly, as it ferments and decomposes, it probably supplies carbonic acid to the roots of the plants, and so assists the action of the atmosphere and the rain, both in directly supplying carbon and in dissolving the alkalies and other minerals in the soil. The objection to dung as the sole supply of the farm is that it is expensive to make, bulky to move, and always insufficient in quantity; and on these accounts the chemist and the farmer have done their best to find some cheaper means of keeping up the fertility of the soil, and the supply of the food of the people." Such being the natural advantages possessed by well-made farmyard dung over every other kind of manure, it is worse than unpardonable to neglect the best means of collecting and storing it for use.

In connection with this all-important question, I may add that, in that amusing book, "How to Farm profitably; or, the Sayings and Doings of Mr. Alderman Mechi," after enumerating the losses sustained by farmers by the use of too much seed, the writer observes: "Then there was money wasted in another way,—in the washing, drying, and mangling of their dung-heaps." He goes on to state that "he did not put out his to be washed, dried, and mangled; but he took them from out of his tank, or from under his animals, and carted them directly on the land, and ploughed them in, intermixing it all, in every possible way, with various particles of

soil. He found, practically, that taking dung out of the yard after it had been well washed by the rains, and then making a heap of it, to be again well washed and dried, and then again to be moved and carted on to the land, was a great waste of time, and consequently of money."

Here, however, Mr. Mechi, with his usual boldness, assumes as a real advantage that which, hitherto, has been deemed simply a matter of speculation; some scientific agriculturists asserting, like the alderman, that it is more advantageous to apply farmyard manure to the soil in a fresh state; others, on the contrary, consider it is better to apply it after it has been well fermented in the dunghill. Professor Voelcker and other men of eminence seem to lean to the former opinion, while Johnston and others incline to the latter; with which view I also am disposed to concur. Dr. Voelcker (in the *Quarterly Jour. of Agric.*, 1857, p. 155) states it as his opinion, that the loss sustained by spreading farmyard dung upon the land in a fresh state, even for a considerable period before it is ploughed in, is by no means so injurious a practice as we have hitherto been led to suppose. He says that, "on all soils with a moderate proportion of clay, no fear need be entertained of valuable fertilizing substances becoming wasted, if the manure cannot be ploughed in at once. Fresh, and even well-rotted dung, contains very little free ammonia; and, since active fermentation, and with it the further evolution of free ammonia, is stopped by spreading out the manure upon the field, valuable manuring matter cannot escape into the air by adopting this plan."

All that we can gather from the foregoing remarks is this,—that where the land contains a moderate propor-

tion of clay, the loss is not so great as we have been led to suppose. Nevertheless, the writer admits that there is a loss, even upon *moderately-clayed* lands. But what is that loss upon lands that do not contain a moderate proportion of clay? Here I apprehend—nay further, I know—that the loss of ammonia is very considerable. All that Alderman Mechi's dictum is worth is, that he saves a little time and trouble, and consequently expense, by leading his manure upon the land in a fresh state, instead of putting it out to "wash and mangle," as he jocularly designates it. But, with all deference to him, I must beg leave to demur even as to the point of saving of time and trouble. Mr. Mechi leads out his fresh manure in a state of long straw, for he tells us that "he does not chop his haum; he could not afford it." Now I think every practical farmer will bear me out in the assertion that long manure requires a much larger amount of labour to plough in and bury than short; and therefore, so far as labour is concerned, I am inclined to think that the benefit gained by Mr. Mechi is like a saving at the tap and letting it run out at the bunghole.

But I have a much greater objection to the spreading of manure upon the land in a fresh state. We all know that manures lose weight during the process of fermentation; but this loss is not nearly so great as it is when the manure is freely exposed to the sun and air in a fresh state; and, moreover, its action upon the plant is not so immediate. Fresh dung must be decomposed in the soil before plants can appropriate it as food; but rotted dung, from its being so much more soluble, can be appropriated immediately. Neither will Mr. Mechi's "washing" objections serve him, seeing that fresh dung spread upon the soil cannot rot without the

aid of moisture, and that moisture must come from the clouds; and therefore, after all, Mr. Mechi does in reality "put his washing out," instead of doing it at his own copper at home; his washing, in fact, takes place in his fields instead of in his dung-heap. And if his be a clay farm, through which soil the water cannot readily percolate, the loss will be so much the greater.

I have already stated that manure-heaps should either be covered over, or other means be taken to prevent their fertilizing juices being washed away by excessive rains. In ordinary seasons, the rains will rarely be found to be injurious, seeing that the amount of ammonia they bring down with them will pretty nearly compensate for what they may wash out, which at least is a saving of one substance; and if the directions given in a former portion of this chapter be followed, there need be no loss at all.

In support of what I have advanced, I here subjoin the results of two experiments made by Lord Kinnaird in 1851 and 1852:—

"Lord Kinnaird found that two parts of the same field, dressed with equal quantities, the one manure prepared under cover of a roof, and trodden down by cattle, the other manure from the open fold-yard, gave, in—

	Covered.	Uncovered.
1851	11¾ tons	7½ tons of potatoes.
1852	54 bushels	42 bushels of wheat.
1852	215 stone	156 stone of straw."

Whenever Mr. Mechi shall be able to furnish an account *per contra*, showing a saving of labour to the same amount, I promise to reconsider the matter; till then, however, I must be excused if I stick by the old

muck-heap. One other remark to my farming friends: Don't be afraid of Mr. Mechi's washing-bill, only take care to see that the suds are not lost, but that they are taken up and thoroughly incorporated with either soil, ashes, or any other absorbent (lime excepted); and then you will not fail to secure much better crops than you will from saving a few shillings, and carting out your dung fresh from the fold-yard, and spreading it at once upon the land.

COMPOST-HEAPS.

In point of importance, compost-heaps rank next to the dunghill; the only superiority of the latter is owing to its being composed of richer materials; seeing that a great portion of them are composed of corn, bran, and other nutritious substances, rich in both the organic and inorganic constituents of plants, and possessing, in addition, the advantage of having become partially decomposed in passing through the body of the animal. Nevertheless, if compost-heaps are properly put together, and well managed, they are but little inferior to farmyard dung. And I speak advisedly when I say, that if sufficient trouble be taken to collect weeds and other vegetable refuse (instead of burning the former, which is too frequently the case), and then to throw them into a heap for the purpose of making compost, not only would a large amount of valuable manure be obtained, but the farmer would in many instances be relieved from the necessity of purchasing expensive artificial fertilizers. "A weed," says Dr. Bucknill, "is but a plant out of place;" and I am quite sure my readers will all agree in thinking that they are out of place when found with their wheat and other crops.

Yet, noxious as they indisputably are, they are not altogether valueless, and many of them, as I shall presently show, when properly decomposed, afford most valuable fertilizing constituents. Professor Voelcker (who so ably fills the position of consulting chemist to the Royal Agricultural Society) reminds me of an Indian sportsman I once met with, who with his double-barrelled gun let fly at everything that came in his way, from a snipe to an elephant. So with the learned professor, he brings his analytical battery to bear with equal force upon the most important plant and the most contemptible weed, and herein does most important service. I find in the *Journal of the Royal Agricultural Society*, vol. xviii. p. 351, the following analysis of two very common and very troublesome weeds; viz. couch-grass and the stemless thistle. One hundred parts of the ash of the former gave on analysis the following very highly-fertilizing ingredients:—

Carbonate of potash	14·10
Potash in a state of silicate	0·27
Soda in a state of silicate	5·69
Chloride of sodium	3·34
Oxides of iron and alumina	12·40
united with phosphoric acid	9·38
equal to bone-earth	(20·32)
Sulphate of lime	9·06
Carbonate of lime	3·30
Magnesia in a state of silicate	0·04
Soluble silica	24·92
Insoluble silicious matter (sand)	17·50
	100·00

A slight glance at the foregoing analysis will be sufficient to show that couch-grass is rich in many of those ingredients in which most cultivated soils are

deficient, and which are expensive to purchase; for instance, it contains more than 14 per cent. of carbonate of potash; it contains constituents equal to more than 22¼ per cent. of bone-earth, and very nearly 25 per cent. of soluble silica, so necessary in adding to the strength of the stem of all cereals. The ash of the stemless thistle was found on analysis to give—

Potash and chloride of potassium	27·40	in 100 parts.
Chloride of sodium	0·90	
Lime	41·44	
Magnesia	4·40	
Oxide of iron and alumina	2·01	
Phosphoric acid	5·36	
Sulphuric acid	2·92	
Soluble silica and sand	3·50	
Carbonic acid and loss	12·07	

Here it will be seen that lime forms the principal constituent; but it will also be seen that potash enters largely into the constituents of the ash of this plant, as also does phosphoric acid. Now it is a fact well worth the serious consideration of the farmer, that these two constituents form a very important item in the money value of every artificial manure he purchases; and they are, as he will find when we come to treat of artificial manures, the very ingredients in which many of them are especially deficient. And here, also, it may be important to state that all the mineral constituents of plants are much more valuable, when they can be obtained in a soluble state by natural decomposition, than they are when that state of solubility has to be brought about by artificial means.

Before proceeding to lay down a few rules for the manipulation of compost-heaps, a few general observations upon weeds may not be out of place, seeing that

their destruction in the compost-heap is by far the best and most economical way of getting rid of them; it is dangerous to use the dung-heap for this purpose, as their seeds and roots there are not always effectually destroyed: besides, the thing would be impossible if Mr. Mechi's plan were to obtain general practice.

To the farmer, then, everything is a weed which is out of place, and has a tendency to obstruct or injure the crop he wishes to cultivate. A blade of wheat is as much a weed in a crop of turnips as a thistle, and more mischievous too, inasmuch as it absorbs more valuable fertilizing matter. For our purpose, weeds may conveniently be divided into two classes,—first, the *annuals*; and second, all that have a longer existence, which may be comprehended under the general name of *perennials*. These again may be divided into such as propagate by their roots and such as propagate by their seed. It is almost unnecessary to specify such weeds as couch-grass, knot-grass, and the like: all farmers know how impossible it is to produce a good corn crop upon soil overrun with these, and how difficult it is to eradicate them. The roots of couch-grass are particularly long and full of juice, and withal so tenacious of life, that if but one single joint be left in the soil, it never fails to strike and spring up. To get rid of this pest, there is nothing for it but hand-picking, after ploughing and harrowing. In the latter process I would recommend a harrow made expressly for the purpose, having round instead of square tines, as not being so liable to cut the roots, and therefore more likely to bring them out in longer pieces. Docks and thistles every one knows how to manage; but as these propagate by their seeds, and as those of the latter are furnished with wings and fly away to immense

distances, care should be taken to grub them up before the seed becomes ripe and fit for reproduction. For pulling up thistles I saw an excellent contrivance a short time since in Lincolnshire. In appearance it resembled a large pair of garden-shears; but instead of being furnished with blades for cutting, it assumed the form of a long pair of nippers, opening and shutting like a duck's bill, only much longer, hollowed in the centre, and sharply pointed, so as easily to penetrate the soil. These were opened just sufficiently wide to encompass the root of the plant; thrust in that position into the ground; and with a vigorous pull out came the root entire. With these few remarks upon weeds in general, we will now suppose them all to be collected. It is a very common, though, nevertheless, a very unthrifty practice, to burn them in a heap; as by so doing every 100 lbs. produce no more than about 2 or 3 lbs. of ash; and that is generally left upon the spot on which it has been burnt, until by repeated rains the whole of its soluble properties (chiefly potash) are wasted. A far better plan is to make them into a compost-heap.

On the subject of compost-heaps, Dr. Bucknill* gives the following valuable advice:—

"The first thing is to secure a wide-spreading roof, to prevent the wash of the rain, and the consequent solution and removal of the saline ingredients. Under this roof must be accumulated vegetable refuse, weeds, leaves, turnip-tops, stubble, ditch-scourings, &c., and loamy porous soil (the more porous the better), road-scrapings,

* See the *Journal* of the Bath and West of England Agricultural Society for 1855, p. 94.

old mortar, old cob-wall, &c. &c.; the earthy and vegetable matter being in about equal proportions by bulk. They should be spread about three feet in depth, thoroughly mixed and well watered with liquid manure. In the course of two or three weeks, salt should be added, in the proportion of 1 ton to 20 or 30 tons of compost; and at this time also material containing lime, but not in a caustic state, forms a useful addition. Lime ashes spread about and exposed for some days, being watered, or old mortar, is the readiest way in which it can be used. After these materials have been well mixed in, the mass, which will have shrunk considerably, must be made into long parallel heaps, about 3 feet high and 4 feet wide, with a small space between each; and thus they must lie, watered from time to time with liquid manure or prepared gas-liquor,* and moved from time to time with the fork (to maintain their porosity and supply them with fresh air), for eighteen months, or thereabouts, when the principal portion of the chemical changes will have been effected, and the heap will be ripe for use. The more the heap is moved the better; for by frequent motion alone can its porosity be maintained, and the contact of air with the decayed particles of matter. Its movement will form useful occupation for farming men in bad weather; but it should never be neglected too long at a time. In watering it with liquid manure, urine, or gas-liquor, care should be taken not to make it too wet, as that condition is adverse to porosity. The great object to be kept in view in its management is to maintain the con-

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* For the method of preparing this liquor, see p. 73, under the head of "Ammoniacal Liquor."

stant contact in every part of the mass of air and water, of decaying vegetable matter, and the chemical materials. The prepared gas-liquor may be used at two or three different times: it should be added at least in the proportion of one hogshead to five tons of compost: it will not be easy to add too much of it. The texture of the material should be kept in the condition of moistish brown sugar. Managed in this manner, the material will be in a state to supply any crop with all, or almost all, the food required by its roots. To feed the cereal crops, it may, however, want one thing, viz., the phosphoric salts. Now there is no cheap source for these most important constituents; they must be supplied either by the addition of superphosphate of lime, or other known substances containing phosphoric acid."

Among these may be mentioned, the more strongly phosphorized guanos, coprolite earth, or phosphoric green sand, bran, or the dung of pigs fed on bran. The farmer must either save his phosphorus from the bran of his corn crops, or the bones and excrements of his animals, or he must be content to buy it, and pay a high price for it. In conclusion, I would observe that the farmer who neglects to collect the weeds and other vegetable refuse of his farm, and convert them into compost-heaps, neglects his own interest, as there is no better way of collecting manure at so small a cost, or that will pay him better interest for his outlay.

SPECIAL MANURES.

Salt.—Many farmers use common salt as a manure, without being acquainted with its properties, or at all understanding the right way of applying it; hence it

not unfrequently happens that, instead of good, it does harm; and farmer John, instead of blaming his own ignorance, as he ought, blames the article itself; and therefore farmer Thomas, acting under his advice, will have nothing to do with it. Nevertheless, I can boldly assert that, when properly applied as a special manure, it is both a cheap, active, and valuable fertilizer, while for mixing with other manures it is invaluable.

I am old enough to remember the time when the tax upon salt was £30 per ton, and even then it was used to a small extent in feeding cattle, and as an artificial manure. The value of salt in feeding cattle will be found discussed at large in a subsequent portion of the work. Our business at the present moment is with its properties as a manure. When applied to the soil, the following are some of its effects:—It supplies soda and chlorine to growing plants; attracts moisture from the atmosphere, and resists freezing: it is sharp without being either acid or alkaline; and is both soluble and penetrative. It promotes the putrefaction of vegetable matters when sparingly used, and has a contrary effect when used in excess. When mixed with lime and some of its compounds, a double decomposition takes place, and other, and often more active fertilizers are produced. It keeps the soil moist in dry, and soft in frosty weather, and suits dry soils and seasons when other manures require wet. By its attraction for moisture, it keeps everything in the soil in a soluble state, and so enables plants to take them up with the greatest facility, and it also assists the action of the atmosphere upon them. It further assists the process of assimilation in the soil, and thus fits its fertilizing properties for vegetable nutrition,

and prepares them for enriching the root-sap. By its penetrative properties, it destroys weeds and vermin, and, when used in excess, cultivated plants also.

Its effects on Manures.—When mixed with farmyard dung, the latter has been found more effective for turnips than double the quantity without it; *i. e.*, one-fourth of dung to three-fourths of salted peat-earth, vegetable mould, or decayed sawdust, thoroughly incorporated and worked into a rich soapy state, produced a heavier crop of both turnips and potatoes than the whole four parts of dung alone; a result doubtlessly arising from its assimilative and penetrative qualities. When mixed with a dunghill at the rate of about two tons to thirty, it kills the seeds and roots of weeds, and also destroys both insects and other vermin contained therein, as well as promotes the fermentation and decomposition of the whole mass: neither does it set free the ammonia, like lime. By the double decomposition which takes place when mixed with lime and some of its compounds, soda combined with carbonic acid is produced, which, from their powers of assimilation, possess greater fertilizing properties than salt itself. This mixture also produces muriate of lime (chloride of calcium), which has a stronger attraction for moisture than almost any other compound; while the same mixture promotes vegetable decay much quicker than either of the substances used alone; and hence their combined value in compost-heaps. With gypsum, salt supplies soda and sulphuric acid cheaper than they can be obtained in any other way. In fact, there are but few fertilizing substances that may not be most advantageously mixed with salt.

The effect of Salt upon Plants.—The effects of salt

upon root-crops are greater than upon those of corn, because, in the first place, they contain more of it in their composition; and, secondly, because they require more moisture, which it has the power of attracting. Pastures, as well as roots, are rendered more palatable to animals by it, and more wholesome, in consequence of their being more soluble, and consequently, also, more nutritious. Further, although not an alkali, it has the effect of sweetening sour pastures. This is due to the action of its chlorine upon the leaf; and, as has been before observed, it produces more ear, heavier grain, and firmer straw in wheat, barley, and other cereals, by enriching the sap, and by producing compounds which render the silica in the soil soluble; thereby imparting a stronger stem, not so liable to be laid by heavy rains. It does not accelerate, but rather retards germination; but it enables plants, by improved means of assimilation, to make up for this deficiency, and thus causes them to outrun others not similarly treated; although it is not till a plant arrives nearly at maturity that the beneficial effect of salt becomes fully developed; then its stimulative effects are made manifest, and it is at once seen how it strengthens cultivated plants, and enables them to master weeds by overrunning them. It accelerates blossoming in peas and other leguminous plants, and, by its operation, grain crops come earlier to maturity. These are some of the effects produced by salt upon plants when used alone; but its value is greatly enhanced when used in conjunction with ammonia; as these two salts mutually assist each other in promoting vegetation, by each in turn supplying the defects of the other.

Advantages of Salt in combination with Ammonia.— Salt and ammonia act differently in promoting the

growth of plants. The former retards, rather than forces, the growth of young plants, while the forcing power of the latter is very great (hence the almost immediate effects of nitrate of soda): it produces a deeper green appearance, with luxuriant juicy growth, and, when used in excess, causes corn crops to run to straw, and flag. Salt does not deepen the green, but strengthens the plant in its after-growth; imparts a great solidity to root and green crops; improves their nutritive properties, as before observed; and gives to corn crops more ear, heavier grain, and less straw. Hence it will be seen that ammonia promotes early vegetation, while salt retards it; but, on the other hand, imparts strength, firmness, and solidity—(and here I may observe that there is no safer criterion than weight by which to determine nutrition in all crops). The practical inference, therefore, is, that the two ingredients act more beneficially when used in conjunction than when applied separately; therefore, a judicious use of the two cannot fail of proving of great benefit to the farmer. But there is still another valuable property of salt, which must not be overlooked: it has the effect of greatly improving the quality of injured hay, if applied a few handfuls at a time (about 28 lbs. to the ton), by scattering it with a sieve over layers of the hay at the time of stacking; and, whether the hay be injured or not, it has been abundantly proved that hay so salted is greatly relished by cattle: they eat it with greater avidity, and thrive better upon it.*

* Some years ago a series of letters upon this subject appeared in, I think, the *Plymouth Journal*, from Mr. J. Prideaux, a west-country chemist of great eminence, and a most reliable authority. I made an abstract of them at the time, being struck with their importance, and since then, a farmer (one who really deserves the name) has applied

Mode of Application, and Quantity to be Used.—The following instructions for using salt for manurial purposes, have been kindly furnished me by an old and esteemed agricultural friend; who, for a number of years, has been in the habit of using it largely on his own land.

Quantity per Acre.—"With regard to the quantity to be applied," my informant observes, "my practice is as follows:—If I want to fallow a piece of ground, I first sow it with such a quantity of salt as is sufficient to destroy vegetation,—I generally find from twenty to five-and-twenty bushels per acre sufficient for this purpose. This, however, depends a good deal upon the nature of the soil: sometimes I find less will do, and at other times more is required; I therefore say from twenty to twenty-five bushels, but even thirty bushels may in some cases be found necessary for this purpose. But I must observe this is to be sown broad-cast, and that, too, for ten days or a fortnight before beginning to work the land with the plough. And as to time, I generally choose the autumn, so as to give the salt a better chance of destroying the weeds and grass, without giving them a season in which they can again propagate. When these appear to be all killed, I set the plough to work, and by the time the land is well worked, the salt will be thoroughly mixed and incorporated with the soil, and therefore, by seed-time I always find it reduced to that strength which is best adapted for forwarding the vegetation of whatever crop may be sown upon it. This

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them to practice with uniform success. In the text above I give his instructions for using salt,—not only for manuring land, but feeding cattle.

mode of treatment I have invariably found to answer well, and produce far better crops than others differently treated,—at least, so far as my experience goes. I have also found that I save considerably in labour by this method, as the tough, adhesive clods and lumps which give so much trouble upon strong clayey soils, are much easier broken and dispersed by the action of the salt, and therefore give less obstruction to the harrow, at the first working. In deep loamy dry earth, upon which wheat has grown, after the crop is got in, my custom is to plough the land, and in that state let it lie fallow until the spring, when I cross-plough, and, after a fine harrow, plant with potatoes. As soon as the potatoes are covered with earth, I then sow, as before, eight bushels of salt (4 cwt.) per acre upon them. By treating the land in this way, it is my firm opinion, founded upon years of experience, that a crop of wheat and potatoes may be taken alternately on the same ground for ever.* Upon other corn lands, sown in the usual way, I am in the habit, after spring ploughing, of sowing *eight bushels of salt per acre immediately after the grain is harrowed in.* I find this plan act beneficially in many ways: it improves the soil, and destroys both weeds and insects; and by keeping the land moist, generally secures an abundant crop. I do not, however, recommend eight bushels of salt to be applied to the wheat crop every year,—after the land has had one good dressing, five bushels will be sufficient to keep it in a most productive state.

* With great deference to my friend's extensive practice and long experience, I must beg to demur to this opinion. I do not know the constituents of his soil; but if not well supplied with phosphate of lime, in the shape of coprolite, his plan will soon exhaust it.

"*For Meadow Ground*—I use three bushels per acre, well mixed with about half a ton of ashes, and sown immediately after the hay is got in. This I find to increase both the quantity and quality of the eddish; and the cattle eat it with greater relish than where the salt has not been used.

"*For Pasture Land*—I never use less than *eight bushels* of salt per acre: the coarser it is the better I like it, as it does not rest upon the blade, but at once gets to the roots, and I greatly prefer it when mixed with seven or eight cartloads of earth or coal-ashes, letting it lie for six weeks or two months before using, turning it over four or five times in the interval. This I generally prefer doing in the autumn. Some time since I had a small grass-field, which, from the time it came into my hands, had produced nothing but a very dark-coloured dry kind of grass, upon which neither horses nor cattle would thrive. I had it sown with eight bushels of salt, mixed with about a cartload of ashes and soil, early in March: ever since that time it has been remarkably green, but not so dark as before, and cattle of all kinds relish and do exceedingly well upon it.

"*For the Garden and Hothouse.*—I recommended the use of salt for the garden and hothouse some years ago to a friend and neighbour of mine. The plan he adopts is, to sprinkle a small portion of salt on the surface of the soil after everything which is sown; and, he informs me, that by this system, every description of produce is brought to maturity three weeks or a month sooner than they are under the ordinary mode of cultivation; the various grains are improved in weight and solidity, and the fruits in richness and flavour."

Soot is a valuable and well-known fertilizer; but its

value is immensely increased when mixed with an equal weight of salt. If used in this way to the extent of about twelve bushels per acre, and ploughed in, it is found to exert a most beneficial influence upon all root and grain crops; wheat, parsnips, and carrots are greatly improved by it. This manure (soot) should always be bought by weight; if bought by the bushel, the farmer is sure to be cheated. I never yet (and I have bought some thousands of bushels) could succeed in making the measure tally with the quantity stated. A bushel of soot ought to weigh 21 lbs., if it weigh heavier, adulteration may be suspected. According to Dr. Voelcker's analysis, it contains, in its natural state,—

	Per cent.	Per ton. lbs.	oz.
Moisture	10·620	237	14
Organic matters and ammoniacal salts containing 1·22 of ammonia	46·554	1040	9
Oxide of iron and alumina	15·691	351	7½
Lime	7·840	175	9¼
Magnesia	0·389	8	11¼
Potash	0·318	7	1¼
Soda	0·122	2	11¾
Sulphuric acid	8·670	194	3½
Phosphoric acid	0·259	5	12¾
Carbonic acid	0·497	11	2
Chlorine	1·008	22	9⅛
Soluble silica	4·014	89	14¼
Insoluble silicious matter—chiefly sand	4·159	93	2⅛

The price of soot varies, particularly in large manufacturing towns, in summer and winter; the best time for purchasing cheaply is about September or October. The difference in price will amply pay for keeping. If collected then, and mixed with salt as before directed,

and kept covered over with mould, it will supply the farmer with a large portion of richly-ammoniated manure.

Gas Refuse, or the Residues left in the manufacture of Gas.—Whatever may be the result of the controversy between Baron Liebig and his chemical compeers, as to the value of ammoniacal manures, it would be useless to speculate upon here. One thing is certain, viz., that although a particular soil may contain all the mineral constituents necessary for the growth of plants, and that these may be present in their proper proportions, and in a state of solubility, ammonia is indispensably requisite to the perfection of vegetable growth. And upon soils so heavily cropped as those of England, and where so much of the produce is carted off the farm, the quantity of ammonia brought down by the rain is by no means sufficient to keep up the necessary supply. It therefore becomes absolutely necessary that it should be obtained from other sources. This being so, the question naturally occurs,—From what sources can it be obtained at the cheapest rate? Thirty or forty years ago this would have been an embarrassing question to deal with, but now it is easily answered, seeing that nearly every town, and indeed many populous villages throughout the country, are lit with gas,* and it is in the manufacture

* I can well remember the first public introduction of gas into London, when it was only intended to supersede the use of oil lamps in the public streets. Even for that purpose it was looked upon with disfavour; but when Mr. Windsor first proposed to introduce it into shops and private dwellings, the storm burst out in all its fury, and he was assailed on every hand: deep-thinking mathematicians,—men learned in the law,—profound physicians,—cool calculating speculators,—and shrewd directors of public insurance companies,—all rose against the *movement, in arms.* Fearful forebodings and profound prophecies flew

of coal-gas that ammonia is most abundantly produced. Gas for illuminating purposes is prepared from bituminous coal, by a process of distillation carried on in cast-iron or clay retorts, which are heated to a bright red. A variety of vaporous products are given off during this process, the principal being carburetted hydrogen, sulphuretted hydrogen, carbonic acid, ammonia, and tar,—while the carbon of the coal remains in the retort in the form of coke. Carburetted hydrogen, as it passes from the retorts, cannot be directly used for the purposes of illumination, inasmuch as it contains certain products not only offensive to the sense of smell and injurious to health, but also of such a nature as would condense and block up the pipes through which it is required to pass. The gas, &c., on leaving the retorts, is received in a large horizontal pipe half filled with water (*the hydraulic main*); from this it passes through a series of iron pipes kept constantly cool (*refrigerators*), till it reaches a vessel called "*the condenser*," and in its course large portions of the ammonia, tar, and other vaporous products, become condensed, and by suitable arrangements

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about in all directions. Houses were to be blown down, and people were to be blown up. Fire offices were to be ruined by explosions and fire; and life offices to become bankrupt by so many people being poisoned; and so great was the dismay of one of the latter of these institutions, that they had a set of new tables computed to meet the coming emergency; while "the faculty" boldly asserted (and what does it not boldly assert?) that an extra college would be required to pass a sufficient number of medical men to meet the immense amount of disease which this new project must necessarily produce. In spite, however, of all these sweeping denunciations, the divine command, "Let there be light," predominated over the long chapter of lamentations opposed to it. The people would have gas—and they had it!

are carried into the tar and liquor-tanks. From the condenser the gas passes on to a series of iron chambers called "*purifiers*," and here it is forced through a number of layers of slaked lime and other substances, in a moist state, which have, *or ought to have*, the effect of removing all the sulphuretted hydrogen and carbonic acid; from these it passes through the station-meter into the gas-holder, and is ready for use. It is the residues left in this process, and their properties, that we here have to consider. Of these, by far the most important is the ammoniacal liqour, as it is from this source that the greater portion of the ammonia of commerce is derived. But there are other residues left in the manufacture of gas, of great importance in agricultural operations, which it will be also necessary to consider as we proceed.

Ammoniacal Liquor.—Shortly after the establishment of the Agricultural College at Cirencester, Professor Voelcker analyzed two samples of the liquor procured from the gas-works of that town. From 100 gallons of one he obtained 18 lbs. of ammonia, and from the other 27 lbs. Being struck with this great discrepancy, I made three other analyses; two from different kinds of coal used at the works with which I am connected, and the third from a sample of 300 gallons received from another establishment. On examining the latter sample, I found it so weak that I was led to suppose it had, by some means or other, become diluted, the per-centage of ammonia not exceeding 0·322. This induced me not to place dependence upon it as being the correct standard of the strength of the liquor made at those works. From one description of coal (Appleby's) I obtained 0·748 per cent. of sulphate of ammonia, or rather less than 12 oz. per gallon. From another sample (Cooper's

Silkstones) the mean of five trials gave 1·254 per cent., or about 1 lb. 4 oz. per gallon: this, it must be remembered, is sulphate of ammonia—not pure ammonia, of which we are speaking. Now, if the reader refers to page 24, he will find that 100 lbs. of sulphate of ammonia contain 54½ lbs. of sulphuric acid, 31½ lbs. of water, and not quite 14¼ lbs. of ammonia; worth, in the market, from 15*s.* to 16*s.* per cwt., or about 1¾*d.* per lb. Now, 10 gallons of gas-liquor may be bought for less than sixpence, and as this quantity of liquor will weigh rather more than 100 lbs., and contains about 2¼ lbs. of pure ammonia, it is more than equal to the quantity contained in 15¾ lbs. of sulphate of ammonia, which, at 1¾*d.* per lb., would cost 2*s.* 3*d.* True, the sulphuric acid would be absent, but this could easily be remedied, either by adding the acid itself, or by the use of gypsum or sulphate of iron (green copperas), at the cost of a few pence. But it must be borne in mind that gas-liquor contains ammonia in several states of combination, one of which is poisonous to plants, viz., *sulphuret of ammonium;* and therefore this compound requires to be altered in the liquor before using. This may be effected in several ways: but the plan I generally adopt, as the most simple, is to mix equal weights of salt, green copperas, and spent gas lime together, turning them well over for several weeks before using; I then mix them with the liquor, applying at the rate of about a pound per gallon. By this means, the insoluble sulphuret of iron is precipitated, and the liquor deprived of the greater portion of its caustic properties.* In using

* This is the mode of preparing gas-liquor I would recommend when it is required for use in compost-heaps (see *ante*, p. 60).

gas-liquor in its ordinary liquid form, it should always be mixed with four or five times its quantity of water, and may then be applied at the rate of 100 to 150 gallons of the liquor per acre; *i. e.*, 150 gallons of gas-liquor and 600 gallons of water; and if the farmer dissolves 2 cwt. of salt in this quantity, its value will be greatly enhanced. Treated in this manner, gas-liquor is worth 1*d.* to 1¼*d.* per gallon, and will pay the farmer for leading five or six miles. When applied in its crude state, it scorches up the plant, and if used in excess, destroys it. For grass land, it should be applied in the quantity before stated, by means of a liquid-manure drill, or water-cart, with a proper spreader, about the latter end of March or the beginning of April. It will be found to destroy worms, grubs, slugs, and insects, and will impart a green, healthy appearance to the grass, its effects being visible for several years afterwards. Stock prefer feeding where it has been used, and have been found to do better upon it. A friend of the author's (a scientific farmer), who used it prepared in the above way, some years since, declares that his land has been in better heart, and produced richer crops ever since; and when his stock are turned into that field, they, to this day, pick out the spot where it was applied, and continue to feed upon it exclusively until eaten quite bare. But by far the most profitable use to which the farmer can apply gas-liquor is, to prepare it as before directed, and mix it with his dung and compost heaps.

Gas Lime is a mixture of carbonate of lime and the sulphuret of calcium, containing, also, a quantity of caustic lime; it also contains a considerable proportion of cyanogen, which alone prevents its being used in the

manufacture of sulphuric acid. When newly made, it is injurious to vegetation, owing to the alkaline sulphurets contained in it. But after being exposed for some time to the atmosphere, the sulphuret of calcium absorbs oxygen, and sulphate of lime (gypsum) is formed, and it may then be applied not only with safety but with advantage. It is especially useful in promoting the growth of clover, sainfoin, vetches, and all green crops where gypsum has been found to be useful. When mixed with salt, at the rate of one cwt. of the latter to four of the former, a double decomposition takes place, and sulphate of soda (Glauber salts) and sulphate of lime are formed: this, when mixed with about six or seven times its weight of coal-ashes and soil, and turned over occasionally for six months, forms a very cheap and valuable fertilizer for grass land and all artifical grasses.

Gas Tar is a most complex, but highly useful substance, and, from its strong antiseptic qualities, is extensively used as a paint for rough outdoor purposes. When mixed with gravel, ashes, and a little quicklime, to about the consistency of stiff mortar, it forms a valuable substance for garden-walks, footpaths, stable and barn floors.* When mixed with broken stones, for road-making, it causes them to combine more firmly, so that, after a time, they become a solid mass. It is highly inflammable, and, upon distillation, yields mineral naphtha in considerable quantity; it also produces what is called light oil, so extensively used in preserving timber, and the residuum left is a black resinous mass,

* When used for this latter purpose, time should be given for it to divest itself of the unpleasant smell arising; nor should the floor be used for some time, as it might impart that smell to the corn or other material deposited upon it.

known as mineral pitch. If applied as follows, it makes a cheap and durable floor for stables, cowsheds, and pigsties:—Break up a sufficient quantity of stones, brick-rubbish, &c., and spread them about three inches thick; upon this run a thin mixture of gas tar and coal ashes, in such a state of consistency as will enable it to flow freely into all the interstices; spread it evenly, and, after standing twenty-four hours, riddle over it a little fine sand or coal ashes, and roll it down. In two or three days it will set and become hard, and impervious to moisture, and forms the most durable and cheapest floor that I know of. As to its value as a manure, I am not sufficiently well informed to enable me to speak positively. Mr. Morton, in the "Cyclopædia of Agriculture," p. 964, gives the following as a "particular instance which came under the writer (J. T. W.)'s attention. A quantity of gas tar"—the precise quantity is not stated—"was dug into the trenches," between rows of potatoes, "before the sets were planted; and not only did the crop escape the ravages of the disease, which destroyed others not so treated, but the potatoes were extremely well-grown and of excellent quality. This result was attributed to the antiseptic properties of the coal tar. The changes which tar undergoes when distributed through the soil are not known; but if, as is most probable, it is ultimately decomposed,* it would act simply in furnishing a supply of carbon to the roots of plants, being practically destitute of nitrogen or mineral ingredients." Considering the antiseptic pro-

* I am instituting a series of experiments in order to determine this fact, and if ready in time, the results shall appear in the Appendix to this work.

perties of coal tar, it appears quite conclusive to me that it might be applied with great advantage as a preventive, if not an absolute remedy for foot-rot in sheep, and, being inexpensive (about *2d.* per gallon), nothing can be easier than its application for this purpose. A pen might be made in the ordinary way, surrounded by a few bricks put together with clay or earth, so as to prevent the escape of the tar, and the sheep passed through it, allowing them to stand for a few minutes, so as to enable it to penetrate sufficiently. This tank need not be more than three inches deep, and the sheep would march out with a pair of well-blacked boots, which I am clearly of opinion would do them no harm, but would prevent this most troublesome calamity, to which they are so liable on wet lands.

Lime.—That lime is a valuable fertilizer is a well-established fact; but its precise action is, even to this day, but imperfectly known. The clay-land farmer uses it not only to improve the texture of his soil, by loosening and rendering it more friable, and consequently more easily worked; but he also finds that it produces heavier and better crops of both wheat and roots. The light-land farmer uses it for a different reason, viz., because both his white and green crops are rendered more luxuriant and sweeter by its application; and further, he finds it greatly to assist him in keeping his land clean, and it also enables him to rid himself more easily of that abominable weed, couch-grass. Indeed, upon all soils and all crops it acts beneficially in one way or another; and hence its general adoption. The chemical action of lime may be said to be of a fourfold nature:—
1. All plants require lime in building up their structure, seeing that lime is found in the ashes of all plants, and

in some of them it is present in large quantities; therefore, lime furnishes a portion of their food. 2. Lime sweetens the sour soils, by combining with the acids they contain; and hence that sourness is removed. 3. Lime possesses the power of dissolving or decomposing vegetable matter; and, by this process, the vegetable matter contained in soils is gradually rendered soluble, and thus fitted to feed the growing plant. 4. Lime exercises a similar action upon the mineral particles of the soil, and so fits them also for entering into the roots of growing plants. It is the usual practice to apply lime to the soil in its caustic state, as, by so doing, its action is quicker; but this is open to one great objection, viz., when so applied, it is more difficult to apply it evenly; and further, it does not become so intimately mixed with the soil as it would if thrown on in the finely-powdered state to which it is reduced by slaking. It also exercises a more beneficial influence when mixed with one-third of its weight of salt. Seeing that lime has a natural tendency to sink, it should never be ploughed in deeply, but should be kept as near the surface of the soil as possible; besides, in this way, it has a better chance of destroying slugs, grubs, &c.

For peaty soils and heavy clay lands, however, I would advise lime to be applied in its caustic state; but, in doing this, I would first screen it, and apply the finer particles to such soils, and reserve the larger lumps for slaking and applying to other descriptions of land, particularly hill pastures, &c. The beneficial action of lime is felt to a much greater extent upon dry or well-drained land than upon wet or imperfectly-drained soils. If land has not been limed for a considerable number of years, a large dose may be requisite,—say, 150 bushels

per acre; and in this case, ten to twelve bushels per acre will be sufficient, if added every rotation: moreover, between each application the soil should receive two good heavy dungings with farmyard manure: by this process the land would always be kept in good heart. When lime is intended to be used upon bare fallow, it should be applied in autumn, immediately before sowing wheat; but if intended for a green crop fallow, it should be put on immediately before the grain crop is sown in spring; and the stronger the soil, the larger the quantity of lime required. "The best indication to the farmer that he must begin to re-lime his land, is the appearance of the corn marigold, general weediness of the surface when laid down to grass, and, above all, an increased tendency to run to couch-grass."—(Morton's *Cyclopædia of Agriculture.*)

The question, as to how far it may be expedient to use lime with farmyard dung, is still unsettled. For my own part, I am inclined to think that the practice is not so dangerous as some are disposed to imagine: I readily admit that to mix lime and farmyard dung together in the open air would be highly prejudicial, as the whole of the ammonia would be thereby dissipated; nor do I think that they could be beneficially used together upon light lands; but I really think that they may be ploughed in together upon strong clay soils with advantage, as the power of clay to absorb and retain ammonia is well known; and therefore I consider it most probable that whatever ammonia the lime might set free, the soil above would absorb and retain; while the other parts of the dung would become more thoroughly decomposed, and rendered more fit for being taken up by the roots.

"Lime," observes the author previously quoted, "is found to act in a remarkable degree upon the turnip crop. Land that has never been limed, or which has not been so for a great number of years, either refuses to grow turnips, or, if they do grow, they are always sadly injured ultimately by the disease called 'fingers and toes.' We have seen so many instances of this disease being removed by lime, that we cannot look upon it in any other light than as a sovereign specific in *all* cases of the same nature. We may, no doubt, produce the 'finger and toe' disease by a too frequent repetition of turnips on the same field, although even recently limed; but, had it not been limed, under such circumstances the disease would have been much more virulent."

Quality of Lime.—Lime, like everything else, differs in quality; and this arises either from the nature of the stone from which it is made, or from the fact of its being well or badly burnt. A good limestone, well burnt, ought to lose about half its weight in burning, and ought to gain about one-third its weight again upon slaking. From this it will at once be seen that a bushel of lime is not always a bushel of lime, but a bushel of lime and limestone mixed, the latter part being next to valueless. It is, therefore, plain that a farmer had better pay a higher price for lime that will slake readily, and nearly all fall, than pay half the price for such as will not more than two-thirds fall. Besides, badly-burnt lime always weighs heavier, and, as we have just stated, limestone ought to lose about one-half its weight upon burning; therefore the more imperfectly it is burnt, the heavier it weighs; consequently, the heavier the weight per bushel, the worse the quality of the article. The best way for a farmer is to purchase his

lime by the chaldron of 36 bushels. Nothing is easier than to detect the difference between well and badly-burnt lime: if a bushel of each of the two kinds be slaked, and the unslakable residues weighed, the difference will at once determine their relative values.

Lime has been termed a means of "enriching the father and beggaring the son," in consequence of its rendering active in a short time all latent permanently fertilizing substances in the soil; and thus, if used largely, it will very speedily exhaust them. I mention this in order to show the danger of using it too profusely, or without following it up with heavy dressings of farm-yard dung.

BONES.—If those persons who are in the habit of sneering at science, when compared with practice, will only for a few minutes turn their attention to bones, they will find the laugh not altogether on their side. In my endeavours to obtain the best possible information upon the subject of bones as manure, I have got together a collection of books sufficient to form, by themselves, no inconsiderable library. I find bones incidentally mentioned as far back as 1770, prior to which period I can discover no allusion to them. It might, perhaps, gratify the curiosity of some, but could serve no useful purpose, were I to give extracts from any works of a date earlier than 1812; I shall, therefore, pass over the whole period from 1770 to 1812, prior to which bones were laid in ruts and broken by cart-wheels, chopped with hatchets, or broken by hammers. But, in 1812, Mr. Strickland informs us that they were applied in a broken state to the extent of from 60 to 70 bushels per acre, at a cost of 2*s.* per bushel. It may, however, be stated as a singular fact, that about the year 1740 the value of

bones as a fertilizer was made known by accident; it thus happened:—

The cutlers of Sheffield, who used bones largely in the manufacture of handles for knives and forks, threw the refuse of their turnings, scrapings, and planings, into large heaps, and these remained undisturbed for a long time, until they became putrefied. At length one of these heaps required to be moved to make way for some new buildings about to be erected, and the bone refuse was carted away as rubbish. By mere accident it was spread upon grass-land, when its fertilizing effect was such as to "astonish the natives;" but, even then, they little thought it was owing to the waste which had been spread upon the land, and not a few of the good folks attributed it to some grand manurial agent *below the surface*, before unknown; accordingly, with that enterprising spirit which has always characterized Sheffield people, they at once began to dig for more of it, but not finding it there, they came to the natural conclusion that the extraordinary crops produced (for by this time there were more than one of them) had been occasioned by the heap of "rubbish" which had been spread about. Of course the experiment was repeated, and thence the value of bones as a fertilizer became an established fact. The demand rapidly increased, and extensive researches were made in the neighbourhood of Sheffield; old pits and holes which had been filled up with this material, then considered valueless, were re-opened, and large excavations made, in order to recover every particle of this valuable fertilizing material. About the year 1814, machinery was first used for crushing bones, by, I believe, Mr. Legard, of Ganton, on the wolds of Yorkshire, and the success attending

this operation, imperfect as it then was, led to further improvements; steam-power was at length applied, and the crushing of bones became an established trade.

Space will not permit of my extending this short account of the introduction of bones as a fertilizer; I will, therefore, at once proceed to speak of their properties. This would be an easy task were all bones composed of the same constituents, in the same proportions; but this is by no means the case, seeing that they contain less earthy matter when young than when old. The quantity of carbonate of lime which they contain also varies materially. The following analysis of the bones of an ox may be taken as containing their average constituents.

Cartilage	33·3	per cent.
Phosphate of lime	55·35	„
Fluate of lime	3·0	„
Carbonate of lime	3·85	„
Phosphate of magnesia	3·05	„
Soda and a small portion of common salt	2·45	„

Human bones, particularly those of young children, differ very materially from this analysis; but as human bones are not usually ground up for manure, so far as I know, we will not stay to examine them. The value of bones as manure in their raw state (we shall speak of boiled bones hereafter) may be thus defined: first, in the cartilage they contain, which is very rich in nitrogen, inasmuch as 100 lbs. of cartilage will furnish, on decomposition, 22 lbs. of ammonia; and as one-third of the whole weight of raw bones of average quality, as shown by the above table, is composed of cartilage, 100 lbs. of raw bones contains nearly 7 lbs. 4½ oz. of ammonia; this also contains carbonic acid and sulphur in a state of combination before decomposition. Further, it will be

seen by the foregoing table that bones contain more than half their weight of phosphate of lime, and also phosphate of magnesia, the value of which we have before shown (see p. 36). It is, therefore, clearly manifest that bones in their raw state are rich in every ingredient required as food for plants. But, when boiled, or in what is called "the *dry* state," this is not so; as by the process of boiling they lose the whole of the cartilage, and are consequently deprived of nearly all the ammonia they contain. And, as they are generally used in the dry state in the manufacture of super-phosphate, the action of this manure is greatly assisted by ammoniacal compounds.

There are many substances soluble in water, when broken into small particles, which are insoluble in their perfect state. Bone is one of them, glass is another: a wine-glass may be immersed in water for any length of time without being dissolved, but put it into a mortar and reduce it to powder, and it will lose a portion of its weight every time fresh water is added to it; its insolubility in the first instance is owing solely to its mechanical texture; but when powdered, this mechanical texture is destroyed, and it becomes soluble; so it is with bones,—and hence their more immediate action the finer they are ground. If bones were readily soluble, and they could be evenly spread, so as to give the plant the full benefit of their constituents, half a hundred-weight would be amply sufficient for an acre of wheat; but this is not so in practice, and therefore a larger quantity is necessary. By boiling bones, as I have before observed, the gelatine and fatty matter is extracted, and this, although it diminishes their fertilizing properties, renders them more ready to submit to the action of the atmosphere and water; and thus the

fertilizing substances which remain come more immediately into action, and they are, therefore, often preferred as a manure, particularly for turnips, where the great object is to force the young plant into broad leaf, so as to escape the ravages of the fly. The same remark, indeed, which is applicable to bones, applies equally to every other manure,—the more soluble it is the more readily is it taken up and assimilated by plants, and therefore the more rapid its action. This fact will account for the great estimation in which super-phosphate, or dissolved bone, is held.*

On dissolving bones by the agency of sulphuric acid, their mechanical structure is destroyed, and their earthy constituents are rendered so soluble as to be easily taken up by plants, and become immediately available. In addition to this, sulphuric acid is in itself a valuable fertilizer, for it enters largely into the constituents of some plants, particularly swedes and cabbage (see *ante*, p. 37), and, moreover, it has the effect of rendering other fertilizing substances in the soil soluble, while it has also the power of fixing carbonate of ammonia, by converting it into a sulphate, which, though readily soluble in water, is not volatile, like the former.

The high estimation in which dissolved bones are justly held has so greatly increased their consumption,

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* The credit of the discovery of dissolving bones is generally accorded to Baron Liebig—with what justice I must leave others to determine: but I find by the *Annales de l'Industrie* of 1824, that M. Darcet, at Paris, was engaged in the same operation. He submitted raw bones for some hours to ebullition in boiling water, to remove the fat, after which they were treated with dilute muriatic acid, to dissolve the phosphate of lime and magnesia and the carbonate of lime; but whether he applied these as manure is not stated.

that there is scarcely a town of any note throughout the kingdom, that does not contain a "super-phosphate manufactory." Now, this manufacture opens a very wide field for adulteration; and as many there be, unfortunately, who do not feel themselves bound to conduct their business upon strictly honest principles, and who are content to sell an inferior article rather than none at all, such men do not hesitate to take advantage of that patent weakness of all farmers for cheap bargains,* and consequently, do not hesitate to mix this so-called super-phosphate with all manner of rubbish, so as to enable them to undersell the respectable manufacturer. For this there is but one remedy of a really practical nature, and that is to deal with none but parties well known for the honesty and integrity of their dealings. In offering this caution to farmers, I can assure them that adulteration, in both raw and boiled bones, as well as super-phosphate, is carried on to a much greater extent than they are aware of. I was told a short time back by the

* A manufacturer of an excellent artificial manure complained, the other day, to the author, that in his trade it was hardly worth while to be honest: for he found that the manures produced by certain other makers, which he knew from analysis to be vastly inferior to his own, were just as readily bought by the farmers at the same price. In illustration of this, I will mention a fact that came under my own observation in a Yorkshire market. I saw a respectable manufacturer of super-phosphate, whose article I had examined, and knew to be genuine, offer it to a farmer with whom he had done business for eight or nine years; but the latter objected, as he thought the price (£7 per ton) was too high. Shortly after an agent offered him a super-phosphate for £6 per ton. He forthwith bought of him seven tons. I procured a sample from the bulk, analyzed it, and found it to contain, among other matters, 67·53 per cent. of gypsum, worth in that market 10*s.* 6*d.* per ton.

proprietor of some extensive gypsum quarries, that his best customers were the super-phosphate manufacturers and bone-crushers. This fact is pregnant with warning to farmers.* But if, after all that can be said, any man will be so foolish as to risk his root-crops for the sake of saving some six or eight shillings per acre, he has no one to blame but himself, and nothing but bitter experience will teach him better. If, however, he must have a low-priced article, let him purchase a smaller quantity of the very best, from a manufacturer of established reputation, *and adulterate it himself*; he is quite as capable of doing this as the manufacturer, and at less cost. A few cwts. of sifted ashes, a bag or two of gypsum, a sack of sawdust and another of salt, and the job is done. With these at hand he may lower a good manure down to a bad one. By this plan, too, he may at once convince himself of the comparative values of the good and bad article, by simply testing their effects upon a few square yards of the same soil and crop, using weight for weight, and afterwards weighing the produce, and calculating the money-value of each.

In order to show how greatly the super-phosphates of commerce vary in their composition, the following analyses of three samples (*vide* Sibson's *Agricultural Chemistry*, p. 181) have been selected from numerous others made at the Agricultural College at Cirencester:—

* A bone-crusher remarked in my hearing the other day, "Why, if we can't make a little money out of these fellows, who are we to make it out of? They beat us down to the lowest farthing, and after taking six or twelve months' credit, they never pay without grumbling, and saying the stuff 'did them no good.'"

COMPOSITION OF SUPER-PHOSPHATE OF LIME.

	No. 1.	No. 2.	No. 3.
Water	20·53	14·40	0 91
Organic matter	14·76	8·93	—
Soluble phosphate of lime	10·31	3·60	25·70
equal to bone earth	(16·09)	(5·61)	(40·11)
Insoluble bone phosphate	17·72	6·83	6·68
Hydrated sulphate of lime (gypsum)	28·39	44·23	55·43
Alkaline salts	1·56	2·52	·96
Sand	6·73	19·50	2·32
	100·00	100·00	100·00
Per-centage of nitrogen	·853	1·44	—
equal to ammonia	1·065	1·75	—

"No. 1 may be accepted as an example of a good super-phosphate: it contains about a third of its weight of phosphate of lime, one half of which is rendered soluble by acid; the other half of this phosphate may be regarded as unchanged bone material, and, provided the manure has been made from bones, this insoluble phosphate of lime will be of the same value in the soil as bone-dust; but if, as often happens, mineral phosphate of lime has been used in the manufacture, this quantity left unchanged will be worthless, or nearly so, when applied to the land. The essential material is, in all cases, the phosphate of lime, soluble in water, and the value of the sample is chiefly regulated by the proportion of this material. The organic matter—the more or less altered gelatine of the bones—depends for its value on the nitrogen it contains, or the ammonia it is capable of producing by decay.*

* The following table will show the values per ton of the whole of the ingredients contained in the foregoing analysis, and may be taken

"No. 2 is altogether the reverse of No. 1. It contains but a small quantity of soluble phosphate, and very little insoluble; an undue quantity of gypsum, and far too much sand. This is an adulterated super-phosphate, and is worth but a fraction of the price charged for it. From these examples it will be seen that the value of a super-phosphate entirely depends on its quality, and, in most cases, on the proportion of soluble phosphate of lime it contains. Thus, a sample like No. 3 is not dear at £12, because it contains £12 worth of fertilizing materials; whereas sample No. 2 would be dear at £5. It should always be remembered by farmers in purchasing super-phosphate, and, indeed, all other kinds of artificial mixtures, that the dearness or cheapness of a manure is not determined by its price, but by the amount of fertilizing materials it contains, and the degree of fitness of these materials for action in the soil."

Seeing the extent to which adulteration is practised by super-phosphate makers, in common with many other artificial-manure dealers, the farmer may perhaps feel inclined to manufacture his own super-phosphate; and this he may do both easily and profitably by attending

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as representing the value of those materials in whatsoever analysis they may appear.

Organic matter	£1	per ton.
Soluble phosphate	33	,,
Insoluble phosphate*	7	,,
Sulphate of lime	1	,,
Alkaline salts	1	,,
Ammonia†	56	,,

* If there be mineral phosphates, they are nearly worthless.

† This is pure ammonia, not the ammonias of commerce, which are always combined with an acid.

to the following directions. The most economical way is to begin some months before it is wanted; for though bones may be rapidly dissolved by means of sulphuric acid, that is both a somewhat dangerous and expensive process. Bones, though not readily dissolved by water, yield rapidly to the action of common salt when mixed with urine, gas-liquor, or any of the salts of ammonia. Let us suppose a farmer to require bones for his turnip crop in the spring; let him lay in his stock of bone-dust, say 2 cwt. per acre, in the December previous. Let him mix these in a shed, or any covered place, with the same weight of salt, and to this add 20 bushels of finely-sifted coal-ashes, and water them with gas-liquor, or liquid manure from his tank, if he have one, and turn them over every week or ten days: the quantity of liquor to use should be as much as they will absorb. This process, repeated for three months, will reduce them to a proper state, and, by the time they are required for use, he will have, at least so far as bones are concerned, a sufficient supply to procure him an excellent crop. And now let us see the cost per acre.

	£.	s.	d.
2 cwt. bone-dust, at 6*s*. 6*d*.	0	13	0
2 cwt. salt, at 1*s*.	0	2	0
20 bushels coal ashes, at 1*d*.	0	1	8
40 gallons of gas-liquor, at 1*d*.	0	3	4
	£1	0	0
Labour, say		3	0
	£1	3	0

Here, it will be seen, at a cost of £1. 3*s*., a farmer may supply himself with a sufficient quantity of super-phosphate for an acre of either swedes, turnips, or mangolds,

and if he only take care that his bone-dust is genuine,* he has no occasion to fear adulteration.

If, however, as is too frequently the case, the farmer will not "take time by the forelock," and look out ahead, but prefers waiting till the last moment, even then I would recommend him to dissolve the bones he may require, sooner than trust to the uncertain compound he often purchases, as before mentioned. For this purpose, time being short, he will be obliged to have recourse to sulphuric acid. And here again he is likely enough to be imposed upon; and, as no article varies more in point of strength, it will be necessary for him to be very particular in making his purchase. He should therefore be careful in ascertaining its specific gravity. If under 1·720, it is not worth ¾*d.* per lb.; if 1·840, he may give 1¼*d.* per lb. for it, that being about the market price for acid of that strength. Having procured his materials, he should proceed as follows:—In a large square tub, say 5 ft. wide by 2 ft. 6 in. broad, and 2 ft. deep (lined with lead), the bones should be spread evenly, and upon them should be poured half their weight of water, if hot all the better; after steeping for 24 hours, then pour on the same quantity of acid; viz., half the weight of the bones. These should now remain 36 hours at least, and be stirred at intervals during the time, when they should be taken out and mixed with ashes to such an extent as will make them sufficiently dry for drilling. The more they are stirred while under acid the better, and the more thoroughly they are mixed with the ashes the better also; as, by so doing, the whole mass becomes more thoroughly incor-

* See Appendix B for the means of detecting adulteration in bone-dust.

porated. Although this method of preparing super-phosphate is more expensive than the former, I am inclined to think that it is, for the generality of soils, preferable, seeing that the sulphuric acid added is in itself valuable, as it forms an important constituent in all crops, but is often very deficient in soils, particularly in chalk lands, where, by setting free the carbonic acid, it enables plants to absorb it for their own benefit specially; and it also acts beneficially by dissolving other substances in the soil necessary to vegetable nutrition.

On the purchase of bones a few hints may not be without their value. The smaller the sizes into which bones are crushed, the greater their commercial value,—not only on account of their greater weight per bushel, but on account of their more immediate action. And as a much greater amount of labour is required to reduce bones to powder than to break them into half-inch sizes, the extra price charged for bone-dust is not to be complained of. A bushel of bone-dust usually weighs 3 or 4 lbs. more than a bushel of half-inch. Now, in the process of crushing half-inch bones, a portion of dust is obtained at the same time. It is by no means an uncommon practice for the crusher, by the use of sieves, to take as much of these smaller particles out of the mass as possible, as by this means he diminishes the weight without decreasing the bulk in like proportion; so that, in the purchase of 20 quarters of bones, the farmer is really tricked out of about 5 cwt. of their best portion, and yet he gets full measure for his money. If in purchasing bones the farmer is led to believe that he is fairly receiving them

small and large together, this is little better than a fraud; if, however, he orders half-inch, he has no right to complain if he gets what we have described above. Whenever crushed bones are quoted a little under the market price, the farmer may be sure that this system of sharp practice is about to be tried on. The bone-crusher buys all his bones by weight, and there is no reason why he should not sell them in the same way. To buy by the ton, and sell by the quarter, bears the impress of fraud upon the face of it; and it is a practice that should be repudiated by every farmer. A fair price for the labour of crushing, and a reasonable profit upon the article, none can object to; but every one must condemn a system originating in duplicity, and continued in deception.

Some bone-crushers have the audacity to state that the finer particles are not so valuable as the coarse, inasmuch as they contain all the sand and other impurities, and moreover, are chiefly composed of the softer portions of the bones, and such of the old bones as are partially decayed. This is simply untrue, as the phosphate of lime is found in the largest proportion in the interior or softer part of the bone, and in the cartilaginous parts towards the surface; and it has been found that, after bones have been ground tolerably fine and sifted, the dust that falls is richer in phosphate of lime than the larger portion remaining. In fact, the dust contains more phosphate of lime than half-inch bones, weight for weight, or measure for measure. The advice I offer to farmers, is to buy their bones in the rough by weight, and stipulate for the price of crushing a certain size; then bargain to have the whole produce,

both fine and coarse. If under the circumstances fraud is practised, the crime is punishable, and the purchaser has his remedy at law.

Coprolite is another material containing a large portion of phosphate of lime; but its use alone would be next to valueless, seeing that, as a mineral phosphate, it is all but insoluble in water. It is, however, extensively used in the manufacture of super-phosphate, the action of sulphuric acid being such as to render the phosphates it contains soluble, and fit for promoting the growth of plants. But it is inferior to bones, even for this purpose, seeing that it is destitute of any organic constituents capable of producing nitrogen; consequently its use is exclusively confined to the manufacture of super-phosphate. It is, however, rather richer in phosphate of lime than any bones that have come under my notice.

Wood Ashes.—It is a matter of surprise that wood ashes, containing so large an amount of fertilizing constituents as they have been found to possess, should be recklessly wasted to the extent they are. They possess all the mineral ingredients required in the production of new wood, and most of those required for the growth of cereals. In addition to the potash they contain, they are especially rich in phosphates, though these vary considerably in different kinds of timber. As a general rule, the ashes of the oak are of the least, and those of the beech of the greatest value—the ashes of oak containing only about 6 per cent. of phosphate, while those of the beech have been found to yield as much as 20 per cent. of their whole weight of this valuable fertilizer. The ashes of the fir and the pine contain from 10 to 15 per cent. of phosphate. While 100 lbs. of the washed ashes of the

beech contain as much of the same material as is to be found in 4 cwt. of fresh human excrement, sufficient for the growth of 4,000 lbs. of wheat straw, or 2,000 lbs. of grain.—[L.P.] Morton's *Cyclopædia*, p. 155.

Coal ashes, though not so valuable as those of wood, are still of great value to the farmer, as they all contain the leading inorganic compounds required as food for plants. Like wood ashes, they vary considerably in their qualities, according to the coal from which they are produced. However, this difference is of degree only, as they all contain lime, magnesia, sulphuric acid, alumina, oxide of iron, phosphoric acid, and silica.* They are found valuable as a top-dressing for leguminous crops; and clover, vetches, and other artificial grasses are greatly benefited by their application, due, most probably, to the lime and sulphuric acid they contain; they also possess the power of absorbing ammonia; and the oxide of iron in their composition enables them to remove the offensive odour arising from night-soil, which

* Coal ashes have been analyzed by Dr. Fowne (*Jour. Roy. A. S.*, vol. iv. p. 541), and found to contain—

Ashes from	Stafforddsh. coal.	Newcastle coal.
Sandy matter and unburnt charcoal ..	64·00	87·60
Oxide of iron and manganese, alumina and some phosphoric acid	9·80	3·60
Carbonate of lime (chalk)	12·80	1·00
Sulphate of lime (gypsum)..........	2·44	0·45
Alkaline sulphate, with traces of chloride, and sulphuret	0·40	1·26
Water	8·80	4·60
Loss	1·76	1·04

These, mixed with a little oil, have been successfully drilled for turnips.

should never be used without their being mixed with it. In addition to their fertilizing properties, they exercise a beneficial influence upon strong soils by their mechanical action, having a tendency to render it more friable and less difficult to work; and, by opening the texture, to expose them more freely to the action of the sun and air. Upon light soils, their beneficial action is not so freely admitted, and it is still doubtful whether their application is advantageous or not. Limited space will not permit of my enlarging here upon this subject. All who wish to be more fully informed thereon, should consult Morton's *Cyclopædia*, article "ASHES."

ARTIFICIAL MANURES.

The manufacture of artificial manures is now carried on to such an extent as to render it a matter of paramount importance that the farmer should have some reliable guide to direct him in his purchases.

In comparison with the number of plants with which botanists are said to be acquainted (some 150,000), there are but few from which we derive food, and these for the most part are grasses. Of these, none of them grow to perfection unaided: they all require culture and the assistance of man. There is no soil (or at least none with which I am acquainted) that is adapted to the production of these plants continuously without artificial help. The potato, for instance, indigenous to some portion of the coast of the South Pacific, in its natural state produces two crops per year; but, in point of quality, it is small in size, rank in flavour, and of a sad, hard, and waxy nature when boiled, and in every respect so inferior to that highly-esteemed esculent of British

production, that hitherto it has not been much cultivated in its original soil as human food. Wheat, again, so far as I know, grows nowhere as a natural plant in the perfection produced by cultivation; and hence we may infer that, originally, agriculture was found to be necessary to enable the soil to produce those plants requisite for the food of man and animals, instead of such as it would have produced naturally. As the plants required as food are but few in number, in comparison with such as the soil produces spontaneously, and as these are of a most exhaustive character, the soil requires to be continually assisted by the application of manures. But as all plants do not exhaust the soil of the same substances, or to the same extent, it is perfectly clear that a correct knowledge of the means of altering the condition of the soil, so as to enable it to produce the plants required, may be considered the essence of skilled agriculture.

The last twenty years have done much to promote the science of farming; and the genial spirit in which agricultural improvements have been embraced by the more intelligent portion of the community engaged in such pursuits, has had the happy effect of greatly advancing our national prosperity. But it is to the appearance of Liebig's "Agricultural Chemistry," in 1840, that we may attribute the complete revolution that has taken place in our farming operations. The few venial mistakes made by him are of trifling import, when compared with the immense amount of good he has conferred by his laborious investigations, and by his happy application of chemical knowledge to agriculture. No sooner did his work appear, than the egg of Columbus was found to stand on end, and one of the most notable consequences of the system he had so popu-

larly developed was, that all the world became manure-makers. It is not my intention to devote much time or space in commenting upon the numerous and, for the most part, next to worthless compounds, which, from time to time, are introduced to the notice of farmers as artificial fertilizers. Yet, from "the increasing demand for these manures, the general favour in which artificial fertilizers are now held; the deficiencies of natural sources from which a really valuable manure can be prepared; disregard for the difference of the practical effects of a manure and its real money value; and the difficulty of arriving, in a single season, at a positive conclusion with regard to its efficacy, and other similar circumstances, are fruitful causes of the shameful adulterations in artificials of recognized value, and of the many inferior and worthless compounds which are found in the manure-market at the present time,"* it becomes imperatively necessary that some effectual check should be put upon practices not only reprehensible in themselves, but disastrous in their consequences.

Without particularizing any one of this numerous class of nearly valueless compounds, I shall content myself with a brief description of one or two of the most specious of these compositions—calculated, by their alluring titles, to lead the unwary farmer to entertain a very exaggerated opinion of their merits; particularly when supported, as they usually are, by a long list of flattering testimonials; and then proceed to the more agreeable task of commending such of those as are of well-ascertained value and uniform quality.

* Voelcker's Lecture.

Before proceeding, however, to the performance of this disagreeable duty, it is necessary to state that many artificial manures are actually bought and sold in the market at more than double the price, not only of what they are worth but at which they are manufactured with great profit, particularly such as are composed almost entirely of saline ingredients, which mostly contain from 30 to 40 per cent. of water. An artificial compound of this character was some time ago brought prominently under my notice by the receipt of a very plausible prospectus, with an unusual array of testimonials. This manure (like many others) professed to be a "cheap substitute for guano," the cost being about £2 per ton less, and the quantity to be used per acre about one-third. As a general rule, I scrupulously avoid what is termed "cheap and nasty," upon principle; but in this case, thinking it just possible that the manufacturer of this manure might have discovered something of which I was ignorant—some residue of a manufacture for instance, which had hitherto escaped my notice, and which might contain the large percentage of ammonia this composition was said to possess—I therefore determined to see what it was like; and in order to have a fair sample, I procured, through a friend in London, a cask of the article as though for practical use. On its receipt, I subjected one portion to a careful analysis myself, and forwarded another portion to a friend for a similar purpose, so that the operations of the one might check those of the other. The quantity analyzed by each party was 35 lbs., and the average results are here given in lbs. per ton:—

		lbs.	oz.		lbs.
Water	in 35 lbs.	12	4	per ton.	784
Sulphate of lime and magnesia	,,	0	5	,,	20
,, iron (green copperas)	,,	8	5	,,	532
,, soda (Glauber salts)	,,	5	4	,,	336
Bi-sulphate soda	,,	3	12	,,	240
,, potash	,,	1	10	,,	104
Sulphate ammonia	,,	0	14½	,,	58
Sand......................	,,	2	9½	,,	166
		35	0		2240

For this article, composed of the above-mentioned materials, and in the quantities above stated, the price charged to me was at the rate of £12 per ton. Let us now see what would be the wholesale cost of the respective materials used, in the market, if purchased at the present time.

	lbs.	£.	s.	d.
Water	784	0	0	0
Sulphate of lime and magnesia..	20	0	0	3½
Green copperas	532	1	2	2
Glauber salts	336	0	18	0
Bi-sulphate soda..............	240	0	9	9
Bi-sulphate potash............	104	0	10	10
Sulphate ammonia............	58	0	7	3
Sand........................	166	0	0	0
		£3	8	3½
Add for grinding and mixing, per ton ..			6	8½
		£3	15	0

How a compound containing only 5 per cent. of a weak salt of potash, and rather more than 2½ per cent. of sulphate of ammonia, without one grain of phosphate, can be considered as useful, either as a top-dresssing for wheat, or as a manure for turnips, I am at a loss to conceive. There are some soils, doubtless, upon which

this manure might possibly have a beneficial effect; but even supposing it to be very beneficial to every description of soil and crop, still, composed of the ingredients above stated, and sold at the price charged, there can be no economy in using it, especially as it could be well afforded for one-third of the sum.

The following is a careful analysis of another of these highly-lauded fertilizers—the quantity tested being the same as before, and procured in like manner, the price charged being £8 per ton.

		lbs.	oz.	per ton.
Water	in 35 lbs.	8	4	528 lbs.
Sulphate of lime (gypsum)	,,	7	13	500 ,,
Chloride of sodium (salt)	,,	5	11¼	366 ,,
Sulphate magnesia (Epsom salts) ..	,,	2	1¾	135 ,,
Organic matter (chiefly soot)......	,,	6	4¾	403 ,,
Insoluble mineral phosphate of lime (coprolite)	,,	1	4	80 ,,
Insoluble silicious matter (sand) ..	,,	3	9	228 ,,
	lbs.	35	0	2240 ,,

The real money value of this mixture, which, as to its fertilizing powers, stands pretty much upon a par with its predecessor—indeed, rather below it,—may be estimated as follows:—

	lbs.		£.	s.	d.
Water	528	....	0	0	0
Gypsum............	500	....	0	4	6
Salt	366	....	0	3	8
Epsom salts	135	....	0	6	6
Soot	403	(19 bushels) at 8*d.*	0	12	8
Coprolite	80	....	0	3	6
Sand	228	....	0	0	0
			£1	10	10
Add for labour in mixing, &c. per ton ..				9	2
			£2	0	0

In this, as in the former case, comment is superfluous, and little better than an insult to the understanding; yet still, from the avidity with which compounds of this character are bought, one would almost be inclined to fancy that the farmer took a pleasure in being cheated; and verily, if he feel disposed to indulge in so expensive a luxury, he need not remain inactive for lack of opportunity, seeing that every market is inundated with manure-agents anxious on all occasions to palm off wares, something like Hodge's razors, "made to sell," —and if so foolish as to buy, he cannot complain if he be often rather roughly *shaved*.

The expense of a guinea for an analysis might save him pounds; but this he considers a species of extravagance, and rather than incur it, he prefers to pay enormously for an article which he could easily prepare for less than one-third of the price. But my object in earnestly calling the attention of farmers to this question is really not so much to put them on their guard against deception, as to impress upon their minds that they have within their own reach all the ingredients (with the exception of a few inexpensive materials) requisite for the growth of crops, if they will only husband and use them properly; and by so doing they would require but little aid from the manure-maker. But the nature of the soil, as well as the kind of crop to be grown upon it, as I have already observed, must be duly considered, or else no beneficial result will be obtained; for it is impossible to compound any one manure suited either for all crops or all soils.

However numerous may be the class of puffing manufacturers of nearly worthless fertilizers, it is some consolation to know that there are, engaged in the pre-

paration of artificial manures, men of sterling integrity, high principles, and scientific attainments, men who possess the requisite knowledge as well as the means and appliances to compound good articles, and the fairness to sell them at a reasonable profit. Men of this class *do not puff* their wares; their manures do not require the adventitious aid of plausible testimonials; and even if not always or immediately successful (Peruvian guano, indeed, sometimes fails), their value is sure to manifest itself in the following crop.

It is of great importance that the farmer should be enabled, from a published analysis, to form a correct estimate of the money value of a manure. And it is to be regretted that, owing to the fluctuations constantly taking place in the market, no really accurate table for this purpose can be prepared; the following, however, may serve as a rough guide.

TABLE FOR DETERMINING THE MONEY VALUE OF ARTIFICIAL MANURES.*

(*The prices here given, we should observe, are considerably above the present market quotations.*)

			Per ton. £.	s.	d.
1. Nitrogen in the form of ammonia	8*d.*	per lb.	83	0	0
2. Nitrogen in animal or vegetable substances	6*d.*	,,	56	0	0
3. Nitrate of soda	2*d.*	,,	18	13	4
4. Phosphate of lime (bone earth)	1*d.*	,,	9	6	8
or phosphoric acid alone	2*d.*	,,	18	13	4
5. Soluble phosphate of lime, or bi-phosphate of lime	4½*d.*	,,	42	0	0

* Extracted from Professor Voelcker's lecture.

		Per ton. £.	s.	d.
6. Salts of potash	1½d. per lb.	11	13	4
or potash alone	2d. „	18	13	4
7. Gypsum	1d. per 10 lbs.	0	18	8
8. Lime	1d. per 12 lbs.	0	15	7
9. Carbonate of lime (chalk)	1d. per 25 lbs.	0	7	6
10. Magnesia	1d. per 10 lbs.	0	18	8
11. Organic matter (humus)	1d. per 20 lbs.	0	9	4
12. Common salt	1d. per 10 lbs.	0	18	8

Mr. Nesbit's Estimates.

Nitrogen	at £74	per ton.
Ammonia	„ 60	„
Phosphate of lime	„ 8	„
„ „ made soluble	„ 24	„
Organic matter	„ 1	„
Alkaline salts	„ 1	„
Sulphate of lime	„ 1	„
Silica	no value.	
Carbonate of lime	no value.	

As there is a considerable discrepancy between the prices of some of the articles mentioned in the foregoing tables, the best way to estimate the approximate market value is to split the difference.

The following table I have myself prepared, to show the value of the respective ingredients in the form they are mostly used in the manufacture of artificial manures, according to the present market price, their value being rather over than under stated.

Sulphate of ammonia	£14	per ton.
„ soda (Glauber salts)	6	„
„ magnesia (Epsom salts)	7	„
„ iron (green copperas)	4	„
Soot	4	„
Soda ash	9	„
Nitrate of potash (saltpetre)	37	„

Cubic petre (nitrate of soda)	£17	per ton.
*Coprolite (mineral phosphate of lime)	5	„

Sulphuric acid, according to strength, viz.—Specific gravity 1·720, £5. 15s. per ton; 1·820, £7. 10s. per ton; 1·845, £8. 5s. per ton.

GUANO.

This important article, which now forms one of the principal items in the expenditure of nearly every farmer, is withal so various in its quality, that a standard by which to judge of its comparative value has become quite essential, and of paramount importance, in order to enable the purchaser to lay out his money safely and to the best advantage;—especially as, from the high price which guano commands, as also from its varying constituents and different appearance (samples from the same cargo frequently differing in colour and texture), a wide field is opened for adulteration. To whatever extent this may be carried on abroad, I am inclined to think it is more extensively practised among ourselves: "mixing-houses," as they are called, are daily becoming more numerous, and the amount of fraud practised is much greater than is generally imagined. In addition to this, it is liable to sustain damage in the transit, and also to casualty in collection, in consequence

* The following are analyses of two samples of coprolite from Essex and Suffolk:—

	Green sand.	Suffolk.
Phosphate of lime	60·24	56·10
Carbonate of lime	14·36	15·20
Alumina	5·25	6·10
Sand	11·15	10·30
Oxide of iron	4·00	7·05
Moisture	5·00	5·25
	100·00	100·00

of which it often contains an undue admixture of earth, sand, and even pebbles.

Mr. Way gives the following as the analysis of an average sample of Peruvian guano:—

Moisture	13	per cent.
Organic matter, containing 17 per cent. of ammonia	53	„
Alkaline salts, containing 3½ per cent. potash	9	„
Phosphates	24	„
Sand	1	„
	100	

As we can obtain water and sand for nothing, without going half round the world for them, their presence is not only valueless, but is so much loss in weight, besides augmenting the cost of carriage. The organic matter derives its chief value from the ammonia it contains, and this (see *ante*, table, p. 104) may be valued at 6½*d.* per lb.; in like manner, the phosphates should be valued as bone-earth, *i.e.*, at 1*d.* per lb.; and the potash may be taken at its full value, viz., 2*d.* per lb. This being done, the calculation will stand, within a fraction, thus:—

		s.	*d.*	
Ammonia	17 lbs. at 6½*d.*	9	2½	
Phosphate	24 lbs. at 1*d.*	2	0	
Potash	3½ lbs. at 2*d.*	0	7	
		11	9½	per 100 lbs.
		Or 13	3	per cwt.

Or £13. 5*s.* per ton; and if to this 10*s.* per ton be added as the value of the organic matter over and above the ammonia, it will give £13. 15*s.* as the value of the guano, according to the foregoing analysis.*

* The analysis of guano is far too complicated for any farmer to

This mode of calculation applies to artificial manures equally with guano. But, inasmuch as no farmer, probably, has the means within his own reach of testing the manures which he purchases, his best plan is always to buy under the guarantee of a written certificate. On receiving the manure, let him take a fair sample from the bulk—say a pound in weight, from the middle of one or two of the bags, in the presence of a witness. Having done this, he should divide them into two portions, and put them into separate bottles, which, when well corked, and wrapped up, (so as to exclude air and light,) must be kept in a cool place. If he has any doubt as to the quality, let him send one of the two samples to any experienced chemist, who, for a few shillings, will make a rough analysis, so as to show him whether he has been cheated or not; and if the manure proves a failure, let him send the other sample to be regularly analyzed, and, if not found to be up to the published

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attempt. The following remarks upon guanos generally may be useful:—

	Water, per cent.	Organic and Am. Salts, per cent.	Phosphates, per cent.
Bolivian guano contains ..	5 to 7	56 to 64	25 to 29
Peruvian " " ..	7 to 10	56 to 66	16 to 23
Ichaboe " " ..	18 to 26	36 to 44	21 to 29
Saldanha Bay " ..	17 to 34	14 to 22	45 to 56

From this it will be seen that the Peruvian and Bolivain guanos produce the most *immediate*, and the Saldanha Bay guano, the most *lasting* effects.

Guanos are also extensively imported from Patagonia and the Falkland Islands: these are all of an inferior description, and are generally advertised at from £5 to £5. 10*s*. per ton. They are all much deteriorated by the large quantity of rain which falls upon them. Mr. Nesbit has analyzed ten samples imported, and states their average value to be £3. 9*s*. 3*d*. per ton.

analysis, he has his remedy against the party from whom it was purchased.

Dr. Voelcker, in his lecture on artificial manures,* observes, "Genuine Peruvian guano should contain from 50 to 60 per cent. of organic matter, yielding at least 16 per cent. of ammonia, 18 to 20 per cent. of bone earth, 6 to 8 per cent. of alkaline salts, and not more than 2 or 3 per cent. of insoluble silicious matter (sand). Further, genuine guano, on burning, leaves a perfectly white ash" (*I have found it slightly tinged with blue or pearl-grey*), "which does not effervesce with an acid; whilst adulterated guano generally produces, on burning, a reddish-coloured ash, which does not readily dissolve in acid (showing adulteration with gypsum), or strongly effervesces with acid, proving adulteration with chalk."

"But the easiest way to ascertain if Peruvian guano is genuine or adulterated is to weigh a bushel; if pure, it will weigh from 68 to 72 lbs.; if much adulterated, it will weigh considerably more, no cheap material having been discovered with which guano can be readily adulterated, without increasing its specific gravity."† The farmer will also act wisely in avoiding guanos advertised with high-sounding names: they are for the most part resorted to for the purpose of getting rid of guanos damaged in transit, or otherwise to cover adulterations

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* It is a pity this valuable lecture is out of print; it is to be found entire in the "Journal of the Bath and West of England Agricultural Society," vol. iii. p. 72. Even at the cost of 6*s.* it is worth buying.

† Here I must beg to differ with Professor Voelcker. I saw a sample, a few months since, largely adulterated with an article of nearly the same gravity and colour, and which can be bought at about £5 per ton. I decline naming the article in question, for obvious reasons.

at home. In another part of the lecture just quoted, Dr. Voelcker, in adverting to a compound called "The Essence of Guano," observes, "Such an issue of guano lately has been analyzed by us with the following results:—

Composition of the Essence of Guano, sold at £11 per ton.

Water	8·282	per cent.
Organic matter*	13·111	,,
Phosphates and oxides of iron and alumina†	5·947	,,
Sulphate of lime (gypsum)	15·179	,,
Carbonate of lime (chalk)	8·003	,,
Chloride of sodium (common salt)	15·803	,,
Insoluble silicious matter, principally sand and brick-dust	34·297	,,
	100·622	

* Containing ammonia	·643
† Containing phosphoric acid	1·088
and equal to bone-earth	2·357

"It will be observed that, instead of 16 per cent. of ammonia, this "Essence of Guano" contained only 6-10ths per cent.; and, instead of 20 per cent. bone-earth, only 2 and 3-10ths per cent. To make up for this deficiency, no less than 34 per cent. of sand and brick-dust, 15 per cent. of gypsum, 8 per cent. of chalk, and 15 per cent. of common salt had been added (nearly 3-4ths of the whole bulk). A more fraudulent case," continues Professor Voelcker, "has scarcely ever come under our notice. The exceedingly small amount of ammonia (not quite 7-10ths per cent.) shows that, if any, a mere trace of Peruvian guano was incorporated in this worthless mixture, which, indeed, when examined under the microscope, appeared to have been compounded by mixing together gypsum, lime, sand, brick-

dust, common salt, and sheep's dung. So clumsily was the mixture made, that the last-mentioned ingredient could be readily identified by its characteristic globular form."

As there is abundant reason to believe that Peruvian guano is extensively adulterated, judging by the able article to which I have just before alluded, I recommend the following as an additional test to that suggested by Professor Voelcker; and one that will enable the farmer to ascertain whether the article has been adulterated in the way I have mentioned:—Weigh 3 oz. of the article, put this into a common metal pan (a brass ladle will be better), and place it over a hot fire, and there let it remain till everything combustible is burnt away; the ash left, if the sample be pure, will, as I have before stated, be of a pearly white, and weigh one-third of the whole weight. If it exceeds this, and does not answer to the colour, the sample is adulterated; and the greater the departure from colour and weight, the greater the amount of adulteration; if adulterated with the article already hinted at, the ash will be less than one-third of the bulk tested, and of a lightish slate-colour.

With ordinary attention to these instructions, the farmer cannot be defrauded to any great extent; but, in all large purchases, a written guarantee and a proper analysis are strongly recommended, and, in most cases, will well repay the cost incurred.*

* Such of my readers as may desire to be more fully informed on this subject, cannot do better than consult Mr. Nesbit's book on "Natural Guanos."

WASTE MANURES.

I have already had occasion to notice the reckless waste of many valuable fertilizing substances, arising from the farmer being either so ignorant as not to know their value, or so indolent as not to take the trouble of collecting them. I now propose to speak of these more in detail, in the hope that I may do something towards preventing the continuance of a practice so detrimental as this wanton waste of valuable matter. In quantity it is far greater than is generally imagined, and there is an abundance of evidence to prove that, were the waste fertilizers duly economized, they would supply ample material to make such a quantity of manure as would preclude the necessity for purchasing *hand tillages* at all. The farmer can scarcely plead ignorance upon this matter, for the subject has been brought under his notice in various shapes, and in numberless instances, during the last twenty years. Hannam, Milburn, Johnston, Huxtable, and a host of others, have, by their writings and lectures, been for years engaged in pressing this important subject upon the attention of the agricultural community. I regret, however, to be obliged to state that as yet very little good effect has been produced. There are, nevertheless, some honourable exceptions, and these are to be found, naturally, among the most intelligent and successful of our farmers. A slight glance at a farmstead is sufficient to enable any man of ordinary intelligence and observation to tell whether the occupier makes the most of the wash of his premises, or allows it to run off uselessly; and I am sorry to be compelled to report that the result of my observation is that waste is the rule and economy the

exception. We send ships to traverse the ocean for thousands of miles, in search of artificial fertilizers, for which we have to pay at the rate of £10 to £15 per ton, while at the very same time we are letting our own fertilizing agents run to waste under our very noses. France, Belgium, nay, every country in Europe, laughs at us for this. The French taunt us by saying we send to them for dried night-soil to fertilize our land, preferring to let our own escape and pollute the streams from which we obtain water for domestic purposes, "Jean Bull preferring to take it *au naturel*" to manuring his land with it.

I have for years viewed this subject from various aspects, and have come to the conclusion that this reckless waste is attributable to a combination of ignorance and carelessness, with that miserable penny-wise-and-pound-foolish system of reducing the hand labour upon farms to starvation-point. In many parts of the country, in Lincolnshire particularly, there are hundreds of miles of ditches, drains, and watercourses, full of rank vegetable matter, which, if collected and made into compost-heaps, would be sufficient to manure every bit of the land they surround, and yet they are entirely neglected. Sooner than pay for the labour necessary to collect and work them up, the occupier of the soil will spend five or six times the amount for artificial fertilizers. But let us come to particulars, and first notice—

The Waste of House-wash.—This, though not so powerful as the drainage of cattle-sheds, &c., is still of great fertilizing power, and in quantity is far greater than most people are aware of. When the establishment is extensive, and the family numerous, this waste *is of course* very considerable. It was but the other

day I visited a large farmstead, when the first thing that struck my attention was one of the female domestics pouring the contents of a bucket of suds, after washing, into a grate, set most conveniently just opposite the kitchen-door. Being somewhat curious, I determined to trace the ultimate destination of this bucket of suds. I found the grate to communicate with a drain which led to the horse-pond, and from which pond another drain had been considerately cut, which led to a ditch made to receive the surface drainage of the field on the side of which it ran: this emptied itself into a small stream, which led I know not where. Now, however valuable the manure thus wasted might prove in growing water-cresses, so far as the farm was concerned, it was lost.

The wash of a house contains many valuable fertilizing ingredients: soapsuds contain soda and fatty matter; dish-washings, animal and vegetable matters, producing ammonia and salt; and human urine, the most powerful fertilizer known. Now, if we estimate the washings and slops of every description in a house at 10 gallons a day (a moderate calculation), here is a loss per year of 3,650 gallons, which, if worked up with ashes and other dry rubbish, would make a compost-heap of no inconsiderable size, and which, if mixed with farmyard dung, would greatly augment its quantity, as well as improve its quality.*

The Waste by drainage from Dung-heaps I have

* The high importance of these liquid matters cannot well be over-estimated. Mr. Milburn (the late secretary of the Yorkshire Agricultural Society, in the *Transactions of the Highland Society*, 1841) states "*that as much liquid is thus wasted as would have an effect equal to all the hand-tillages employed by the farmer!*"

already noticed, in my remarks on the chemistry of the dunghill; but I may here state that a moderately well-fed beast will produce ten or twelve tons of dung and about 1,500 gallons of urine per year; and the more highly and more nutritiously the animal is fed, the more powerfully fertilizing are its excrements: this is shown in the difference produced from an oilcake-fed animal and one chiefly fed upon root crops. It is also shown in the value of horse-dung; and yet it is by no means uncommon to hear of a farmer prosecuting his servant for stealing corn to give to his horses. To keep a horse upon short allowance, or to blow out his hide with inferior food, is a part of that "penny-wise-and-pound-foolish" system before mentioned, and unfortunately so much in vogue with farmers. Three horses well fed will always be found to do more work and produce more manure, of a richer quality, than four horses badly fed: it is, therefore, idle in the extreme to expect to get four horses' work out of three horses' keep; and yet this species of economy many farmers actually have the ignorance to boast of practising!

The great channels of waste in dung-heaps consist—1st, in the liquid which often is allowed to escape from them, and is thus washed into the drains; 2nd, by evaporation, arising in consequence of their exposure to the sun and air by not being under cover. To obviate both of these losses there is a very simple remedy; and that is, the use of animal carbon. This animal carbon may be obtained, in very considerable quantity, at the rate of from 4*s.* to 6*s.* per ton. It is the refuse of very extensive manufactories of Prussian blue and yellow prussiate of potash: it has the power of absorbing all the ammoniacal and other fertilizing properties of manure,

which are liable to be washed away. A layer, say six inches thick at the bottom of a dunghill, and two inches thick as a covering, will entirely obviate the loss from either source. This article, used in the way here described, will be found very largely beneficial to the farmer: I use it extensively for extracting ammonia from gas-liquor, and recommend its use to my agricultural readers.

Residues from various Manufactures.—I might extend this part of my subject, were I to pursue it, beyond all ordinary limits, so vast and so numerous are the manufactures of England by which manure, to an incredible extent, is wasted. By way of illustration, I will mention only one out of the legion; viz., THE MANUFACTURE OF COKE; and should these pages fall into the hands of any extensive coke-burner, I really hope he will turn his attention to it. Since the introduction of railways, the manufacture of coke has vastly increased, many thousands of tons of coal being used for that purpose alone. Every ton of coal used in this way contains, upon an average, about 100 lbs. of ammonia, at present lost by being dissipated into the air. Now this, by a very simple contrivance, might be all saved, so that the coke-manufacturer would double his profits, and the farmer be enabled to purchase that article at less than one-half its present lowest cost. Here, then, is a source from which an unlimited supply of one of the principal constituents of guano might be obtained at little comparative cost, but which, for want of ordinary care, as we have shown, is now recklessly wasted.

POTASH, one of the most valuable constituents in guano, is also wasted to an enormous extent. It is used by printers for washing their forms after they have been worked; and insignificant as this process may at first

sight appear, it will be considered a matter well deserving attention, when we come to know that the quantity wasted of this important and expensive article by the thirteen London daily papers alone, would, if saved, be sufficient to supply as much of that constituent as is needed in the production of upwards of 8,800 bushels of wheat and its straw. Again, the quantity of human urine wasted at our railway-stations is enormous, although nothing would be easier than its collection: a large tank, a few tons of sawdust mixed with a few cwts. of green copperas to disinfect it, and it might be carted away in a fit state to mix with ashes, and drill, at almost any time, and for any crop. Indeed, if this valuable fertilizer, now wasted by hundreds of tons at our railway-stations, were collected in the manner I have described, we might very likely be spared the cost of sending out ships to remote parts of the world in search of guano.

I cannot better conclude these observations upon manures than by offering a few remarks upon the method of

MIXING ARTIFICIAL MANURES FOR USE.

Next to the quality of the manure itself, mixing it with soil, ashes, &c., is of the greatest importance, and yet so obstinate, so pig-headed, indeed, are a great majority of our farmers, that they will not take the little trouble required to make those manures thoroughly effectual. I speak from extensive observation, and I repeat, there is not one farmer in fifty who applies artificial manures according to the directions given. Many apply them without any mixing whatsoever; a failure is the consequence, and the manure is blamed.

(A farmer has, indeed, a great knack of blaming everybody and everything but his own stupidity!) Others again, instead of taking time for the operation, and mixing the manure with soil, ashes, &c., some ten days or a fortnight before it is wanted, and turning it over two or three times during the interval, so as to thoroughly incorporate the whole bulk, delay sending for the manure until the last moment; they then cart it at once into the field, throw it upon the heap they may have prepared to mix with it, give it one or two turns over with a shovel, and into the drill with it. By this slovenly mode of procedure, the compost is not half mixed; some of the seed gets too much, and some none at all of the manure: a like failure with the former is the result, and again the manure is condemned. I have seen numerous instances where Peruvian guano has utterly failed, solely from this cause. And I may further add here another observation; viz., that a farmer who is slovenly in one thing is generally slovenly in all others; and the only cure for such a man is to *raise his rent*—no other argument will convince him.

The following instructions, if strictly followed, will, in nine cases out of ten, give an increase of produce more than adequate to meet the extra sum the farmer may spend upon artificial manures; and if such manures do not succeed when treated in this way, he will then be justified in blaming them, and not till then. A large proportion of the whole constituents of all artificial manures are, or ought to be, soluble in water; they should therefore be mixed with three or four times their weight of soil or finely-sifted ashes, at least ten days before they are used; and if in a dry state, the addition of as much water as they will bear should from time to time be

applied with a watering-can as they are turned over. This will have the effect of impregnating the whole mass, and thus insure an equal distribution of all the soluble salts at least. The necessity for this will be apparent to any one if he will but think for a moment. Suppose a farmer to be about to apply an artificial manure to his soil, and to use it at the rate of 5 cwt. per acre: if he should use it without mixing, and sow it ever so evenly, he will only have a little over $1\frac{3}{4}$ oz. per square yard; a quantity quite sufficient, if it could be so applied, as an equal proportion of it would come in contact with the roots of the growing plants; but as this is impossible, it becomes absolutely necessary that the manure should be mixed with some proper material, and equally necessary that it should become thoroughly incorporated with that material, in order that its fertilizing powers may be equally diffused throughout the whole mass. By this means the little leaven is made to leaven the whole lump; and unless this be done, no farmer is justified in throwing the blame on a manure when the fault is properly ascribable to himself.

PART II.

CATTLE AND CATTLE-FEEDING.

CATTLE AND CATTLE-FEEDING.

NEXT to the production of food itself, the science of using it is of the greatest importance to the farmer; and much as he may have learnt upon the subject, he has still much more to learn before he can expect to make his farm yield the full amount it is capable of producing; and until he has accomplished this, his work is still before him.

There is no clearer indication of a man holding a farm too large for his capital than the way in which it is stocked. If the stock be equal to the acreage, there is little fear of the land becoming impoverished; but if, as is too frequently the case, a farmer holds more acres than he is capable of stocking properly, his soil *must* become poorer every year. He may purchase artificial fertilizers, bones and other manures; but unless he keeps plenty of stock, he can never farm profitably. If he has not sufficient stock to consume the food produced on the land, the surplus must be sold off the farm annually, and, unless annually replaced by manure, both farm and farmer will become speedily impoverished. It is, therefore, of the last importance to a young farmer to consider well, before taking a farm, whether he has adequate means to stock it and work it to the greatest advantage. "The benefit," says Mr. Young, "to be derived from the occupation of land depends so much upon the farmer commanding the requisite capital, that it is extremely necessary for the young beginner to be well advised on this essential point." But, supposing a young farmer to possess sufficient capital, a few general

hints upon buying cattle and stocking his farm may not be altogether useless.

In the first place he will do well to define his own plans, and determine whether he will rear and feed his cattle for the milk-pail, or for supplying the markets; and if he intend to compass both, it will be important for him to consider to what extent he means to carry on these operations. To determine this matter correctly, it will be necessary for him to ascertain the nature, situation, and fertility of the soils of which his farm is composed, and then carefully consider the proportion between his stock, and the amount of food required for their support. Correct views upon all these subjects are absolutely necessary, seeing that if he should overstock his land, he cannot fail of being a heavy loser; and if, on the other hand, he does not stock his land with as many cattle as it will keep, he will not make the profit he otherwise would, and will also incur the additional loss of having to purchase extra manures.

As to the breed and quality of the cattle he should purchase, I do not presume to offer an opinion. Abler pens than mine, backed by much larger experience, have been usefully devoted to this subject, particularly of late years. However, the following table* cannot fail of proving serviceable, as affording a ready reference to the qualities and peculiarities of the different breeds of cattle, sheep, and swine; while the judicious observations upon the peculiar advantages and disadvantages of the respective breeds, will serve greatly to assist the farmer in choosing that particular breed most suitable to his requirements, and most likely to thrive best upon the farm he occupies.

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* *Extracted* from Mr. Culley's *Synopsis of Breeds*, with some valu*able improvments by* a Lincolnshire grazier.

A SYNOPSIS OF THE BREEDS OF NEAT CATTLE, SHEEP, AND SWINE.

I.—A TABLE OF THE DIFFERENT BREEDS OF NEAT CATTLE IN GREAT BRITAIN.

Breeds.	*Specific Characters.*	*Peculiar Advantages and Disadvantages.*	*Where usually found.*
1. WILD RACE	Horns white, tipped with black; cream-coloured; ear, internally and externally, from the tip downwards, about one-third red; black muzzle.	Flesh very fine, and of excellent flavour.	In Chillingham Park, in the county of Northumberland.
2. DEVONSHIRE .... Descended from the wild breed.	Horns of a middle length, bending upwards; colour light red, with a light dun ring round the eye; thin-faced; hips wide; thin-skinned.	Admirably calculated for draught. Though rather small in point of size, they amply compensate for that defect by their hardiness and agility. They fatten early.	Chiefly in the county whence they derive their names.
VARIETY 1:— Hertfordshire. VARIETY 2:— Sussex.	Colour red; hair fine; thin skin; horns of a medium length, rather curving upwards; head and neck clean; hips, rump, and surloin wide; thin thighs; back straight; chine narrow; small-boned.	Qualities similar to the above. The cows yield a good portion of rich milk.	In the counties of Sussex, and Hertford in particular; also in Kent and other parts of England.
3. DUTCH, or SHORT-HORNED.	Hide thin; horns short; little hair; colour red and white, nearly equally mixed; tender constitutions.	Fatten kindly, yielding large quantities of milk and tallow.	In the eastern counties of England, and in some of those in Scotland which border on the German Ocean.
4. LANCASHIRE	Long-horned; hide firm and thick; hair long and close; neck thick and coarse; colour various, with white streak along the back; hoofs large; fore-quarters deeply made; hind-quarters lighter than those of other breeds.	Hardy. Milk less in point of quantity, but the cream is of a richer quality than that of other species of neat cattle. Slow feeders.	Lancashire, Leicestershire, Warwickshire, and the chief grazing counties.

Breeds.	*Specific Characters.*	*Peculiar Advantages and Disadvantages.*	*Where usually found.*
VARIETY:— Dishley, or that kind selected and recommended by the late Mr. Bakewell.	Characters nearly similar to the preceding; hide thin; leg-bones fine, small, and thin.	Fatten kindly, and in little time, upon the most valuable points, though yielding but little milk for the dairy, and producing little tallow.	In great request in various parts of England.
5. GALLOWAY, or POLLED.	No horns, though a few beasts sometimes have two small excrescences depending from the parts where the horns usually grow; in colour and shape resembling the long-horned race, though somewhat shorter; hide moderately thick.	A most excellent and hardy breed, fattening kindly on the best parts; flesh fine-grained, and well mixed with fat; when castrated, well calculated for draught.	In the county from which they receive their name, and in some of the lowlands of Scotland, whence vast numbers are annually sent to Norfolk and other English counties to be fattened for the market.
VARIETY:— Suffolk Duns.	Polled, or without horns; colour light dun; very lean and big-bellied; small-sized.	Most excellent for the dairy; yielding abundance of rich milk.	Chiefly in Suffolk and the adjacent counties.
6. HIGHLAND BREED or KYLOES.	Generally with horns of middle size, bending upwards; colours various, chiefly black, though sometimes brindled or dun; hair long and close; in other respects not unlike the Galloway breed.	Similar to those of the preceding species, being eminently calculated for cold mountainous situations.	The Highlands and western parts of Scotland, whence great numbers are sent to England to be fattened for sale.
VARIETY:— Isle of Sky Breed.	Small size; in other respects resembling the Kyloes.	Similar, though superior to the Highland race for quick fatting.	Chiefly in the Isle of Sky.
7. LOWLAND BREED.	A mixed race between the Kyloes and Galloways; partly long-horned, partly polled; black, brindled, or dun-coloured.	Very indifferent, but partaking chiefly of the Galloway kindliness to fatten.	Lowlands of Scotland, whence they are annually sent to England to be fattened for sale.

8. ALDERNEY, or FRENCH.	Small-sized; colour light red or yellow; horns smooth and neat; of tender constitution.	Very rich milkers. Flesh yellow, or high-coloured, fine-grained, and of excellent flavour.	South of England, chiefly in the possession of gentlemen.
VARIETY:— Dunlop Breed.	A mixture from Fifeshire bulls and Alderney cows; horns small, and awkwardly set; small-sized; of a pied or sandy-red colour.	Admirably calculated for the dairy, from the richness and quantity of milk afforded by the cows; but not for feeding calves, unless for rearing stock.	Ayrshire, and the west of Scotland.
9. WELSH BREED....	Horns thick, curving upwards; size small; colour chiefly black; bones and shape clean, and well-proportioned.	Quick feeders. Vigorous and well calculated for labour, especially the Glamorganshire sort. Greatly improved by proper selection and judicious feeding.	In the counties of Glamorgan and Cardigan particularly, as well as in other parts of Wales, and especially in the southern English counties, where they are greatly prized.

II.—SHEEP.

A TABLE OF THE DIFFERENT BREEDS AND VARIETIES OF BREEDS OF SHEEP, BOTH NATIVE AND FOREIGN, FOUND IN GREAT BRITAIN.

CLASS I.—SHEEP WITHOUT HORNS.

Breeds.	*Specific Characters.*	*Peculiar Advantages or Disadvantages of the respective Breeds.*	*Where chiefly found.*
1. DISHLEY, or NEW LEICESTER.	Head clean, straight, and broad; body round, or barrel-shaped; eyes fine and lively; body fine and small; pelt thin.	Wool long and fine, well calculated for combing; and weighing upon an average 8 lbs. per fleece when killed at two years old. Fatten kindly and early, being admirably calculated for the market, thriving on pastures that will scarcely keep other sheep, and requiring less food than others. Tolerably hard and vigorous.	Chiefly in Leicestershire and the neighbouring counties, whence this breed is gradually dispersing through the kingdom.

Breeds.	*Specific Characters.*	*Peculiar Advantages or Disadvantages of the respective Breeds.*	*Where chiefly found.*
2. LINCOLNSHIRE ..	Face white; bones large; legs white, thick, and rough; carcass long, thin, and weak.	Wool fine and long, from ten to fifteen inches, weighing per fleece, when killed at three years, an average of 11 lbs. Flesh coarse-grained. Slow feeders, calculated only for the richest pastures. Constitution tender.	In Lincolnshire, whence it receives its name, and other rich grazing districts.
VARIETY 1:— Teeswater Breed.	Bones finer; legs longer; carcass more heavy and firm; back and sides wider than in the original breed.	Wool not so long as that of the preceding sort, weighing about 9 lbs. when killed at two years old. Flesh finer-grained and fatter. Female singularly prolific, generally producing two, and often three lambs each. Constitution weak. Slow feeders, suited only for the finest pastures, consequently less profitable than the smaller-sized but quicker-feeding sorts of sheep. Capable of great improvement by crossing with *New Leicester* or *Dishley* rams.	In the extensive, fertile, sheltered and inclosed tracts of pasture watered by the river Tees, in Yorkshire.
VARIETY 2:— Cotswold, or improved Gloucester Breed.	In most respects resembling the parent breed, but superior.	Wool not so long as that of the original sort. Mutton fine-grained, and full-sized. Capable of great improvement by proper crossing.	Chiefly in Gloucestershire.
3. DARTMOOR, or DEVONSHIRE NATTS.	Face and legs white; neck thick; bones large; back narrow, but backbone high; sides good.	Wool long, weighing upon an average 9 lbs. when killed at about two years and a half. Improves materially by crossing with the *Dishley* breed.	Chiefly on the moors in Devonshire whence they derive their name.
4. HEREFORDSHIRE	Face and legs white; size small; carcass well-shaped.	Wool very fine and short, growing close to their eyes, and weighing, when killed at four years and a half old, upon an average 2 lbs. per fleece. Patient of	In the county of Hereford, where the Archenfield, or true breed, is known by the name of "Ryelands."

		hunger. Flesh fine grained. Constitution tender, requiring shelter in winter. Very profitable, no breed being supposed capable of subsisting on so small a quantity of pasture as this sort requires.	
5. SOUTH-DOWN	Face and legs grey; bones fine; neck long and small; low before; shoulder high; light in the fore-quarter; sides good; loin tolerably broad; backbone rather too high; thigh full; and twist good.	Wool very fine and short (the staple being from two to three inches in length), weighing an average of 2½ lbs. per fleece when killed at two years old. Flesh fine-grained, and of excellent flavour. Quick feeders. Constitution hardy and vigorous. Capable of great improvement.	On the dry chalky downs of Sussex, whence this valuable breed is being gradually introduced into the various districts.
VARIETY 1:— Cannock Heath.	In most respects resembling the *South-down* race.	Wool fine and soft. Flesh fine and sweet. Greatly improvable by crossing with *Herefordshire* rams.	On Cannock Heath, in the county of Stafford, which gives this breed its name.
6. ROMNEY MARSH	Face white; legs white and rather long; bones rather large; body round or barrel-shaped; size good.	Wool fine, long, and white, weighing, when killed at two years and a half old, about 8 lbs. per fleece. Flesh excellent and fine-grained. Fatten early and kindly, but calculated only for rich marsh or pasture grounds, where this breed is very profitable.	On Romney Marsh, whence this valuable sort is denominated, and on the rich marsh-lands of Sussex.
7. HERDWICK........	Face speckled with black and white; legs of the same colour, small, fine, and clean.	Wool short and matted in the fleece, each fleece averaging 2 lbs. when killed at four years and a half old. Constitution very hardy and vigorous, requiring only a little hay during intense winters.	On the mountainous tract at the head of the rivers Esk and Dudden, in Cumberland, where they are farmed out to herds; from which circumstance they derive their name.
8. CHEVIOT..........	Face and legs chiefly white; body long; eyes lively and prominent; fore-quarters deficient in depth on the breast, which is narrow, as also is the chine; pelt thin; bones fine, clean, and small.	Wool partly fine, and in part of a coarse quality, each fleece averaging about 4½ lbs. when killed at four years and a half old. A very hardy mountain breed, well calculated for exposed situations. Fattening kindly.	In the mountain tract termed the Cheviot Hills, whence they have been introduced into the most northern districts.

Breeds.	*Specific Characters.*	*Peculiar Advantages or Disadvantages of the respective Breeds.*	*Where chiefly found.*
9. DUN-FACED	Face of a dun or tawny colour; size small; tail short.	Wool of various streaks, black, red, brown, or dun, and partly of a fine texture, weighing about $1\frac{1}{2}$ lb. per fleece when killed at four years and a half old. Flesh finely-grained, and of excellent flavour. Not so hardy as the preceding sort.	In exposed northern districts.
10. SHETLAND	Very small in size, and of various colours.	Wool very fine and soft, fit for the finest manufactures, the fleece weighing from 1 to 3 lbs. Very hardy, but too wild to be confined.	In the islands whence this breed is named.
VARIETY 1.	Has coarse wool above, and fine wool below, being supplied with long hairs, termed *fors and scudda*, which protect the animals from the intense cold of winter.		
VARIETY 2.	Has a soft cottony fleece, and is less hardy than the preceding variety, the wool being short and open.		

CLASS II.—HORNED SHEEP.

11. EXMORE	Face and legs white; bone, neck, and head peculiarly delicate.	Wool fine and long, averaging about 4 lbs. per fleece. Very hardy.	Chiefly on and in the vicinity of Exmore, in the northern part of the county of Devon.
12. DORSETSHIRE ..	Face white; legs long, small, and white; ewes singularly prolific, bringing lambs twice, and at any part of the year.	Wool fine and short, the fleece averaging about $3\frac{1}{2}$ lbs. when killed at three years and a half old.	In the county from which the name is derived, and in the adjacent districts.

13. NORFOLK	Horns large and spiral; face black; body long, thin, and weak; neck long; legs long, black or grey.	Wool short and fine, weighing about 2 lbs. per fleece at three years and a half, which is the chief quality of this breed, whose flesh is well-flavoured and of a fine grain. Kept chiefly for the convenience of folding.	In the counties of Norfolk and Suffolk, where it is native; but is giving way to the more profitable *South-down* breed.
14. HEATH	Horns like those of the preceding sort; face and legs black; eyes wild and fierce; carcass short and firm.	Wool long, open, coarse, and shaggy; fleece averaging about 3½ lbs. at four years and a half old. Constitution hardy, and superior to that of the *Cheviot* breed. Admirably calculated for elevated, heathy, and exposed districts. Good feeders. Flesh excellent.	In the north-western parts of Yorkshire; the north-eastern counties of England, and thence forward to the western islands of Scotland. It appears to be the same breed which is known in the district of Linton by the various names of *Linton*, *Short*, or *Forest* sheep.
15. MERINO, or SPANISH SHEEP.	Horns of middle size, of which the ewes are sometimes destitute; face white; legs of the same hue, and rather long, shape not very perfect, having a piece of loose skin depending from the neck; bone fine; pelt fine and clear.	Wool uncommonly fine, weighing, upon an average, about 3½ lbs. Constitution pretty hardy. Fatten kindly.	In Spain; whence two flocks were imported to this country; the first in or about 1802, for his Majesty Geo. III., the other by Lord Somerville, at an immense expense. Great benefit has been derived by crossing this sort with the best British sheep.

III.—A TABLE OF THE PRINCIPAL BREEDS OF SWINE IN GREAT BRITAIN.

Breeds.	*Specific Characters.*	*Advantages and Disadvantages.*
1. BERKSHIRE	Colour reddish, with brown or black spots; sides very broad; short legs; ears large and pendent over the eyes; body thick, close, and well-made.	Kindly disposed to fatten, and attaining a large size, but can be kept only where a large and constant supply of food can be procured; otherwise they will dwindle away and yield no profit. Flesh fine.

Breeds.	*Specific Characters.*	*Advantages and Disadvantages.*
2. CHINESE, or BLACK.	Colour mostly black, though sometimes white, tawny, or reddish and brown; size small; neck thick; legs short; body thick, close, and well-made.	One of the most profitable sorts in this island; flesh delicate; fatten kindly on very indifferent food; but very mischievous if not well ringed.
3. GLOUCESTER	Colour white; size large; legs long; having two *wattles* or dugs pendent from the throat; carcass long and thin; skin thinner than that of the Berkshire sort; ill-formed.	A very unprofitable sort, found chiefly in Gloucestershire, Shropshire, and West Devon; supposed to have formerly been the only breed in Britain. Do not fatten so well, nor so kindly, as the Berkshire breed.
4. HAMPSHIRE	Colour chiefly white; neck and carcass long; body not so well-formed as the Berkshire pigs; size large.	Fatten kindly and to a very great size and weight.
5. HIGHLAND, or IRISH BREED.	Size small; bristles erect; ill-shaped	Thrive very badly; prevailing chiefly in the Highlands.
6. NORTHAMPTON ..	Colour white; legs very short; ears enormously large, often sweeping the ground; size large.	Fatten to a large size, but not very kindly; reared chiefly in the county from which they take their name.
VARIETY:— Shropshire Breed.	Characteristics nearly the same; not so well-made as the Berkshire.	Not so kindly disposed as the Berkshire; fatten to a large size. Flesh highly esteemed in the neighbourhood of London.
7. RUDGEWICK......	A singular breed, raised at a village of the same name on the confines of Surrey and Sussex. Very large.	A most valuable sort; fatten very kindly, and to a vast size; weighing, at two years, twice or thrice the weight of other swine of the same age.
8. THE SWING-TAILED BREED.	Colour various; size small, but well-proportioned.	A hardy useful beast, fattening to a good weight.
9. LARGE SPOTTED WOBURN BREED.	A new variety, introduced by the late Duke of of Bedford; size large; colour various; well-formed.	Very prolific, hardy, kindly disposed to fatten, attaining nearly twice the size and weight of other hogs within the same given period of time.

Discarding, as I have already done, any intention to offer specific advice as to what cattle a young farmer should purchase as stock, yet a few general observations may not be inappropriate, as they will have direct reference to the foregoing tables, and in some measure explain the terms used:—

Symmetry of Shape means a form so compact that every part of the animal is relatively well-proportioned. To make up this, the carcass should be deep and broad. The less valuable parts, such as the head, bones, &c., should also be as small as possible.

Flesh.—As a knowledge of this can only be acquired from outward indications by practice, it is sufficient to state that the best sign of good flesh, when the animals are killed, is that of being *marbled*, or having the fat and lean finely veined or intermixed. This is only to be conjectured in the living animal by handling, and thereby ascertaining whether the flesh and the skin have a firm and mellow feel, neither dry and hard on the one hand, nor flabby on the other; but yielding under the pressure of the fingers in what is called an even "kindly" manner.

Breeding.—Sir John Sinclair (a safe authority) says: "Breed only from small-boned, straight-backed, healthy, clean, kindly-skinned, and round-bodied animals, carefully rejecting all having heavy legs and roach backs, with much appearance of offal." There is, however, nothing but practice can teach a farmer this part of his business: the hints here given are with a view to assist him in his operations. But *one rule* I must lay down, and recommend him never to lose sight of it; and that is, *never to buy cattle, whether lean or fat, out of richer or better grounds than those into which he has to turn*

them; if he does, a material loss will be the inevitable consequence. Better by far buy an animal fed upon poor soil, and in a more northern district, at a low price, and bring it to a richer and warmer pasture, where, if it be moderately well-bred, it must improve rapidly, than buy one from a rich soil and turn it upon a poor one, where it cannot but starve and lose flesh: this is particularly the case with aged cattle.

THE THEORY OF CATTLE-FEEDING.

In feeding cattle a farmer has three things to consider, three distinct objects to attain: first, to make *bone;* second, to make *flesh;* and third, to make *fat.* Without bone he can have no flesh, without flesh he can have no fat. Thus they are dependent upon one another: they are all necessary to the support of animal life, and to the full development of the animal. This being so, it is absolutely necessary that in feeding an animal, its food should contain all the elements of bone, flesh, and fat; the two former being plentifully supplied to the growing animal, and the latter when it is being made up for the market. Now, bone has for its elements phosphoric acid and lime; those of flesh are gluten, fibrine, &c.; and of fat, carbon.

These, therefore, it is necessary the food should contain, in their proper proportions, in feeding the animal at its various stages. While young and in a growing state, it requires the bone and flesh-forming constituents; and these are to be found in swedes, cabbage, potatoes, &c., all of which contain a large percentage of phosphoric acid, the principal constituent of bones, and also a considerable proportion of gluten, caseine, &c., the principal consti-

tuents of flesh; but if *flesh* is required to be laid on with a view to fattening, peas, lentils, and other leguminous food should be used. And for *fat* you must have recourse to linseed, and other seeds containing large proportions of oil, starch, gum, sugar, &c. &c., all fat-forming constituents.

The constituents the food ought to contain being known, the next question is the quantity required, as best adapted to promote the growth and sustain the animal, at different periods and under different conditions. Mr. Gyde has published some very useful and practical information upon these points. "An ox," he remarks (*Agric. Gaz.*, vol. i. p. 613), "requires 2 per cent. of his live-weight of hay per day; if he works, 2½ per cent.; a milch cow, 3 per cent.; a fatting ox, 5 per cent. at first, and 4½ per cent. when half fat, and only 4 per cent. when fat; grown-up sheep 3½ per cent. to keep them in store condition. An ox, to replace the daily loss of muscular fibre, requires from 20 to 24 oz. of dry gluten or vegetable albumen daily. This would be supplied by:—

TABLE No. 1.

120 lbs. of turnips.	17 lbs. clover hay.
115 lbs. wheat straw.	12 lbs. pea straw.
75 lbs. carrots.	12 lbs. barley.
67 lbs. potatoes.	10 lbs. oats.
20 lbs. meadow hay.	5 lbs. beans.

The closer the food approaches in its chemical constituents to the flesh it is required to form, the sooner the end will be attained. The following table gives the analysis of 100 parts of dried beef, and also some of the vegetable substances from which it is commonly produced. I may here observe that beef before it is dried usually contains about 77 per cent. of water.

TABLE No. 2.

	Hay.	Oats.	Beans.	Dried beef.
Carbon........	33·47	41·57	38·24	51·82
Hydrogen......	4·20	5·25	5·84	7·57
Oxygen........	32·51	30·10	33·10	21·37
Nitrogen	1·26	1·80	5·00	15·01
Ashes	7·56	3·28	3·71	4·23
Water	16·00	18·00	14·11	—

TABLE No. 3.

100 parts of		Carbon.	Hydrogen.	Nitrogen.	Oxygen.
Mutton fat	contain	78·996	11·700	—	9·304
Potato starch ..	„	44·250	6·674	—	49·076
Gum	„	42·682	6·374	—	50·944
Wool	„	50·653	7·029	17·710	24·608
Horn	„	51·162	6·597	17·284	24·957

From the foregoing tables it will be seen that vegetable and animal substances approach more closely in their chemical constituents than many would be apt to imagine.

The following table will serve to show the relative quantities of flesh-forming and fat-forming constituents contained in an acre of the different crops mentioned :—

TABLE No. 4.

An acre of		*Flesh-forming,* albumen, gluten, &c.	*Fat-forming,* gum, sugar, starch, &c.
Beans, or 25 bushels	contains	450 lbs.	672 lbs.
Peas, or 25 bushels	„	380 „	845 „
Oats, or 50 bushels	„	290 „	1,168 „
Hay, or 3 tons	„	480 „	2,790 „
Potatoes, or 12 tons	„	600 „	3,330 „
Carrots, or 25 tons	„	1,120 „	5,800 „
Turnips, or 30 tons	„	800 „	6,700 „
Wheat straw, or 3,000 lbs..	„	40 „	940 „
Oat straw, or 2,700 lbs.....	„	36 „	970 „
Barley straw, or 2,100 lbs..	„	28 „	646 „

The next table is intended to show the comparative flesh-forming and fat-forming properties contained in 100 parts of each different description of food.

TABLE No. 5.

	Flesh-forming constituents.	*Fat-forming* constituents.
Beans	28·0 per cent.	40 per cent.
Peas	24·0 „	50 „
Barley	112·0 „	60 „
Oats	14·5 „	50 „
Meadow hay	7·1 „	40 „
Clover hay	9·3 „	40 „
Potatoes	2·25 „	12 „
Carrots	2·0 „	10 „
Turnips	1·2 „	10 „
Wheat straw	1·3 „	30 „
Oat straw	1·3 „	35 „

The following table of equivalents may also be useful, as showing how one description of crop may be substituted for another, and produce the same effect in feeding. Taking 100 lbs. of good meadow hay as the standard, it is equal in point of nutrition to—

TABLE No. 6.

Young clover	90 lbs.
Vetches, dry	90 „
Lucern, dry	90 „
Sainfoin, dry	90 „
Potatoes	200 „
Carrots	266 „
Beet-root	460 „
White cabbage	600 „

In reference to the above table, it must be understood that their relative value, as set forth, applies to the elements of nutrition (flesh-forming properties) alone, and not to the elements of respiration or fat-forming properties, the two being entirely distinct. And, al-

though I have mentioned the difference between these two in a former part of this book, it may not be amiss to repeat that the flesh-forming elements contain oxygen, hydrogen, carbon, and nitrogen; while the fat-forming elements are oxygen, hydrogen, carbon, but *no nitrogen*. For the flesh and fat-forming equivalents, Tables Nos. 4 and 5 should be referred to. It would be easy to multiply tables of this description,—I have some eighty or ninety before me, and out of them I have selected the foregoing as being most practically useful. I may state, however, that they all approximate so nearly as to render them all reliable.

SPECIAL FOODS FOR CATTLE.

Mangold Wurzel.—This plant is rapidly superseding the swede-turnip, over which it possesses many advantages. For some years past the swede has been gradually declining, both in point of quantity and quality. "So far as our experience leads us to conclude from having cultivated mangold wurzel for nearly forty years," observes Mr. Baker, of Writtle, "we feel certain that for every purpose it is equal to the Swedish turnip, whilst for feeding oxen and cattle of every description it is vastly superior. Independently of this, the certainty of obtaining a plant, and the small degree of hazard that attends it during its growth, either from insects or drought, render it far more valuable; and the facility with which it is obtained, even during severe frost, places it incomparably before the turnip."

"For a long time, the prejudice of farmers was difficult to overcome. Its best mode of application was not then thoroughly understood, and from giving it too

plentifully to cattle before Christmas arrived, scouring followed, in addition to paralysis of the limbs, from which they recovered slowly; but it is now used throughout the year without any of those disadvantages becoming apparent. Throughout the autumn, the leaves are cut up, and the roots pulped or cut into pieces, and mixed invariably with cut chaff, composed of one part hay and three parts of wheat or oat straw; and cows, oxen, and young cattle are fed upon the mixture, *the whole secret of properly feeding lying in this description of management.* The dry food counteracts the superabundant amount of moisture contained in the roots, and also diminishes the acrid qualities, which at that season, when given alone, act upon the stomach and bowels of neat stock, and produce the disorders before mentioned; and even when, later in the season, it can be given without producing these results, it is always advisable to combine it with dry food, as a means not only of economizing it but also rendering it of greater utility. It can be also adjusted better as regards the quantity given per day; from 56 to 112 lbs. being fully sufficient. About the middle of January the second vegetation commences, and the sugar it contains becomes fixed, and cannot be extracted.* From that period the fattening properties of mangolds become gradually augmented, and continue to increase until the month of June."

The following is the plan adopted by Mr. Baker, and which, from the quantities used, and their respective nutritive properties, cannot fail in proving one of the

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* In manufactories where it is used for extracting sugar, the plant is taken before the second vegetation commences, it being found impossible to extract the sugar after that process has commenced.

best methods of both feeding and fatting cattle:—"I use machines that pluck it into small pieces: these are mixed with a quantity of cut chaff (the quantities are given above), and are moistened by linseed-meal that has been steeped in water 48 hours, at the rate of 3 lbs. to each bullock. In addition, a portion of from 3 to 4 lbs. of barley or bean-meal is added at the time of feeding, each meal being prepared 12 hours previously to the time of using. For store stock, about 56 lbs. (equivalent to a bushel) is given; for fatting-stock, 80 to 112 lbs. per diem.

"I keep a large number of milking cows, which are fed upon it from August to June following. Whenever the leaves can be used, we find an increased quantity of milk. They are invariably cut up and mixed with the roots and chaff, and are the most valuable portion of the plant in its early stages.* As a manure, when ploughed in, they are also beneficial; but, where much live-stock is kept, they can be applied to a more beneficial purpose. In feeding sheep, as well as cows, the roots are best when combined with cabbages or turnips, but should never be given to either without some degree of caution being exercised, as a sudden change of food is apt to cause considerable relaxation of the bowels, which can be mostly avoided by proper management. For sheep before lambing, and for sows in farrow, they cannot be recommended, and for very young pigs they are also not well adapted, but are even injurious. The roots pro-

* If the young stems are gathered, cooked, and served up after the manner of asparagus, they are equally fine-flavoured, and would prove a cheap and lasting substitute for that delicate but somewhat expensive esculent.

duce great heat in the system" (*doubtlessly, from the large amount of carbon they contain*), "and even oxen will, during the most severe frosty weather, be found in a high state of perspiration in open yards; and young cattle invariably fatten upon them better in open yards than when stalled. This may be accepted as an established fact, having myself made several experiments to prove it. With older cattle it is otherwise. There is one point, however, quite certain,—that cattle which have been longest accustomed to mangold wurzel thrive best upon it; and for young weaned calves of two or three months old, it succeeds admirably; still, whenever it can be combined with swedes or common turnips, it is advisable to do so."—*Farmer's Mag.*, vol. xlviii. p. 324.

Its relative feeding value with turnips is as follows:—Turnips, 5*s.*; swedes, 7*s.*; mangolds, 8*s.* per ton.

Von Thaer gives the following table of the proportion of nutritive matter contained in 1,000 parts of—

Swedish turnip	64
White turnip	42
Mangold wurzel	136
Orange globe	135¼
Sugar beet	146¾

General Observations.—All root crops have a tendency to scour, and therefore should invariably be given with a fair proportion of dry food, as one has a tendency to render the other more assimilative, and consequently more immediately nutritious. The advantage of mixing swedes with mangolds, particularly for growing stock, will be at once apparent by reference to the table at page 37. There it will be seen that swedes contain a much larger proportion of phosphoric acid than mangolds, and are therefore better adapted for supplying

the growing animal with bone; but, where cabbage can be grown under favourable circumstances, it will, for all feeding purposes, be found more beneficial than either. So much, however, depends upon the character of the soil and other matters over which the farmer has but very little control, that a great deal will depend upon his own discretion and intelligence.

LINSEED-CAKE, &c.

Under this head, we may class every description of oil-cake. The rapidly-increasing demand for oil-cake, the extensive use of it,* and the high price it commands in the market, open a wide field for adulteration; and true it is, that linseed-cake is more extensively adulterated than any other article of agricultural commerce; and so much so, that the honest manufacturer stands but little chance of competing with the vender of the spurious article; seeing that, from the nature of the adulterants used, their infinite variety, and their great similarity to the genuine seed itself when ground up, the farmer has great difficulty in ascertaining from appearance which is the genuine and which the adulterated article. I therefore propose to point out how, by a few simple tests, any farmer may ascertain for himself whether the sample be genuine or not. Before doing this, however, it may be useful to offer a few remarks upon the various descriptions of oil-cakes now in use, all of which are

* The consumption of oil-cake during the year 1858 was, in round numbers, 90,000 tons, purchased at a cost of about £700,000; while in 1859 the importation of this article amounted to no less than 99,268 tons, and purchased at a cost of rather more than £772,000; showing an increase of £72,000 on the year.

important to the farmer, not only for their fattening qualities, but also from their highly fertilizing properties.

All oleaginous seeds, when under great pressure, yield a twofold product; viz., the oil, and the substances left after the oil has been pressed out. Both of these partake more or less of the characteristics of the plant from which they are derived. The seeds most in use are linseed, rape-seed, poppy-seed, mustard-seed, and cotton-seed. There are, indeed, numerous others; but, as they enter but very slightly into consumption, a lengthy detailed account of their respective qualities is not necessary.

Of the various oil-cakes used either for feeding, fattening, or for manurial purposes, linseed-cake has by far the largest consumption; and, as the next in point of importance is rape-cake, I shall therefore go more largely into detail in considering the composition of these than the others.

As linseed is not extensively cultivated in England, a very large portion of what is consumed is necessarily imported.* In preparing linseed for extracting oil and making cake, it is first of all ground under large stones, revolving round a shaft upon their edges. When ground sufficiently fine, it is subjected to a gentle heat, and put into long hair bags; these again, having the mouth doubled under to keep the meal together, are placed lengthwise in powerful hydraulic presses, capable of sustaining a pressure of many tons, which is exerted by a steam-engine. After the proper degree of pressure has been

* The quantity of linseed imported during the year 1857 was 1,051,118 qrs., at a cost of £3,061,684, being a fraction over £3 per quarter.

applied, the oil is made to ooze out through the bags; this is caught in a spout placed round the press for the purpose, and is conveyed by a pipe into the butts in which it is sent to market. When the oil has been thus expressed, the pressure is taken off, and the residue left is removed from the bags by turning them inside out. As some considerable portion of oil remains round the edges, this is pared off, to be re-pressed, and the remainder is the oil-cake of commerce. Oil-cake is largely manufactured abroad, as well as in England; America, France, Holland, and Belgium producing it in large quantities.

Oil-cake made in England has obtained a marked preference over the foreign sorts, and invariably commands a higher price in the market; but its quality is found to vary greatly, two samples being rarely found alike. In purchasing linseed, the buyer will take care, for his own benefit, that the article be moderately clean, and free from other seeds of less value. Seed of this description, of course, is sold somewhat higher than others; and, in the present state of competition, it requires no ordinary sense of fair-dealing to resist the temptation of using a low-priced seed, seeing that the cake made from an indifferent sort will obtain quite as good a price as that made from a good article; moreover, as the seeds with which linseed is generally mixed all contain oil, but little loss will ensue on this account. The chief reason why home-made cake has obtained an acknowledged preference may be easily accounted for: it is generally fresher, sweeter, and consequently more relished by cattle than foreign cake, which, either from the meal being too highly heated before pressing, or in

consequence of its becoming damaged by sea-air in transit, or from its being kept a long time in stock, perhaps, also, in too damp a place, or from passing through various hands before it comes into those of the farmer for consumption, is apt to get rancid, and acquire a disagreeable smell and taste, very offensive to cattle.

For feeding purposes, the *flesh*-forming properties of linseed-cake are about equal in value with peas and beans, while its *fattening* properties are superior to every other vegetable food of the same cost.

Another advantage English cake possesses over those of foreign manufacture is, that it contains a larger percentage of oil, and is consequently of greater value for producing fat, and thereby commands a higher price. This difference in market value has been the cause of a large amount of adulteration; one of the most common practices being to work up old and damaged cake with a portion of new seed, so as to give it a more mellow and fresher appearance, and to palm it off upon the farmer as English-made cake. I have heard it often asserted that, in the adulteration of oil-cake, sand and other earthy matters are used. From the numerous samples that I am in the habit of continually examining, I have never met with adulterations of this nature, beyond such an amount as might have been occasioned by accident; in fact, adulterations of this character would be so obvious, as to render their detection almost a matter of course; and I think I may say that they are never resorted to, at least by those who make a practice of adulteration. The adulterants generally are the inferior oleaginous seeds; amongst which the brown, or as it is commonly called, "black mustard," rape and

cotton seeds, those of the Brassica tribe, the wild poppy, and others of a more worthless description. In addition to the foregoing, distillers' dregs, particularly those left after the distillation of the beet-root; the carob bean (locust); and, in one sample I had to examine, I found every indication of brewers' grains having been dried, ground, and used as a means of adulteration.

As the feeding value of oil-cake depends very much upon the per-centage of oil it contains, and as this varies considerably in different samples, is is desirable that the farmer should be put in possession of a simple method by which he may be enabled to arrive at the quantity of oil contained in any sample of cake offered to him. A really good sample of oil-cake ought to contain from 10 to 12 per cent. of oil. In order to ascertain whether it does so, proceed as follows:—

1. Weigh accurately 100 grains of the cake, after being reduced to powder by grating and rubbing well in a mortar; put this into a wine-glass, and add a fluid ounce of ether (such as may be obtained from any respectable druggist); stir them well together, and let it stand until the residuum has settled; pour off the fluid, or filter it through a small portion of cotton-wool in a glass funnel, into a separate glass. The ether will speedily evaporate, leaving the oil behind, which, when weighed, should not, as before observed, be less than from 10 to 12 per cent.; though some samples of the best description of English cakes will give as much as 16½ per cent. of oil.

Linseed-cake is, moreover, often adulterated with other substances which are far less costly than oily seeds of an inferior description: the presence of these is best detected by the ash. If adulteration be suspected, the following course should be pursued:—

2. Reduce 100 grains to powder, as before directed; burn this upon a fire-shovel, or in a common brass ladle over a hot fire, till everything combustible is burnt away: the ash left should not, and if the sample

be genuine, will not weigh more than 7 or 8 grains, and should be nearly white.

This is not only a simple but a very good test, but I find very few samples come up to it. Some produce as much as 18 to 19 per cent. of ash, which is either black, or of a darkish slate-colour.

3. To the ash produced, as above, add diluted muriatic acid (spirit of salt); in this, by aid of a little heat, it should nearly all dissolve: if it do not, something wrong is manifest, particularly if a considerable portion of sand remain.

In addition to its feeding properties, cake is valuable also from the superiority of the manure of cake-fed cattle over that of those fed in the ordinary way; such superiority arising from the former containing a large amount of phosphate of lime. To ascertain the amount of this valuable material,—

4. Filter the solution made as above, and add liquor ammonia (spirit of ammonia of the shops) in excess, when phosphate of lime will fall. Pour off the liquid, collect the precipitate, dry, and heat to redness. The weight of this phosphate should not be less than three-fifths of the whole ash left by process No. 2. If it be much less, *do not buy*.

I have before observed that linseed-cake is often adulterated by the admixture of other seeds of an inferior quality; to detect these, the following test will be found effective. It should be first mentioned, however, that the husk of linseed is of a darkish bright-brown colour, approaching to the hue of burnt umber or Spanish brown. Proceed thus:—

5. Break a portion of the cake into small pieces, and add boiling water, frequently straining the whole through a thin linen cloth. After repeated washings in this way, the husks of the original seeds will be obtained in a separate state; these being examined either under the microscope, or through a magnifying lens, will show by their colours whether adulteration has been carried on in this way or not.

The husks of the black mustard, for instance, will be easily detected by their light colour, and those of the other smaller seeds by their black or other colours at variance with that of the genuine seed.

6. To detect adulteration by mustard or rape seed, a different plan must be adopted. If cake be adulterated with mustard or rape seed, it will emit a strong pungent smell when mixed with cold water. The smell is the same in both cases, the mustard, and sometimes the rape, predominating. To distinguish between the two; *the taste* must be resorted to, and in this respect that of the mustard will be found much stronger. As hot water destroys the taste, but not the pungent smell of these two adulterants, it should not be used; but the sample should be tested in both ways, as linseed-cake is sometimes adulterated by both these seeds, after they have been subjected to great heat in the process of manufacture, in order to extract as large an amount of oil from them as possible.

This latter test is not altogether infallible, as if either mustard or rape seed have been heated above 175° Fah., it will no longer give the pungent smell when afterwards powdered and mixed with cold water; and as most of the rape-cake brought to market has been prepared by *hot crushing*, great caution is necessary in forming conclusions.

Rape-cake, in its chemical constituents, resembles very closely that of linseed; it is, however, much more pungent both in taste and smell, and consequently is not relished by cattle. Like linseed it is found to contain, in addition to a variable quantity of oil, a high percentage of phosphoric acid, as well as a large amount of magnesia; these, with its pungent properties, render it, when ground or finely broken, a valuable, and what farmers call a "warm" manure. The late Mr. Pusey used it extensively in sheep-feeding, and stated in the Royal Agricultural Journal, that he found it not so unpalatable to them as to cattle, and he therefore recommended it as a cheap substitute for linseed-cake. The oil contained

in rape-cake is, however, apt to get more quickly rancid than that in linseed-cake; therefore, when purchased for feeding purposes, care should be taken that the cake is fresh. It should be stored in a dry place, exposed to the air as little as possible, and consumed as soon as circumstances will admit.*

Cotton-seed Cake.—This cake is now gradually coming into use, and from its general feeding properties, as well as from its cheapness, it is not improbable that it may ultimately, in a great measure, displace linseed-cake. The great objection to it is, the large amount of indigestible husk it contains, in some cases amounting to 27 per cent. This is not only useless for feeding purposes, but likely to prove absolutely injurious to cattle. Therefore before cotton-seed cake can ever displace linseed to any great extent, the manufacturer must first take care to divest it of the husk it contains, and this he can do only by decorticating the seed before crushing, which will necessarily increase the price of the article to the extent of the husk thus removed. In purchasing cotton-seed cake the farmer should, therefore, exercise great caution as to the quantity of husk it contains; and in this he will be materially assisted by resorting to the instructions given (No. 5) for the examination of oil-cakes, at page 145. If by that process he should find, after drying, more than 10 to 12 per cent., he may be sure the seed

* Mr. Mechi, however, states a fact which seems to ignore this view of the matter. "My sheep and bullocks," he observes, "were eating old rape-cake, which being exhausted, they were supplied with some recently made: not a mouthful of this would they touch; but after packing it away for six weeks the same animals took it readily. The bullocks consume from 5 to 6 lbs. per day. My usual allowance to sheep is 1 to 1½ lb. Fat sheep will eat more than lean ones.—1858."

was not decorticated before crushing, and therefore should not buy. The following comparative analysis, given by Professor Voelcker, of decorticated and non-decorticated seed, will be sufficient to convince those who desire to use it, of the importance of this fact:—

	Decorticated seed.	Not decorticated seed.
Moisture	9·01	10·53
Oil	17·93	6·10
*Flesh-forming principles	41·81	22·62
Woody fibre	8·80	26·96
Gum, sugar, mucilage, &c.	13·67	26·48
Mineral matter (ash)	8·78	7·31
	100·00	100·00
*Containing nitrogen	6·67	3·62

The first column of this double analysis refers to a cake examined by Dr. Voelcker, that was offered at £6. 10*s.* per ton, and the other column to a sample submitted by Mr. Lawrence, offered at £5. 10*s.* per ton. The former sample is worth more than double the price of the latter. The woody fibres also, in the latter, would be likely to prove injurious, and therefore cotton-seed made into cake without decortication is inadmissible as a food for cattle. However, I do not doubt that cotton-seed cake, when divested of its husk, will not only prove a valuable, but a cheap substitute for linseed-cake.

Other descriptions of Oil-cake.—There are other descriptions of cake finding their way into the market, but which have not obtained sufficient importance to call for special comment: there are, however, two which may be briefly noticed with advantage; viz., the cake made from the Carob bean (locust), and that made from

distillers' dregs. The following analyses will serve to show their relative values :*—

Analysis of—	Carob bean.	Distillers' dregs.
Water	12·57	70·45
**Albuminous compounds	3·11	10·80
Sugar	49·68	—
Gum, starch, &c.	12·83	—
Woody fibre	7·0	17·42
Oil	0·41	—
Ash	2·80	1·33
Seeds	11·16	—
	100·00	100·00
**Containing nitrogen	0·47	1·72
The ash contained earthy phosphates	0·34	0·36
Phosphoric acid combined with alkalies	0·05	0·19

Before closing our observations on the value of these different descriptions of cake, it may be useful, for the purpose of reference, to give the following table of the comparative analyses of rape, linseed, poppy-seed, and cotton-seed cakes, as prepared by Professor Anderson :†—

Constituents of—	Linseed.	Rape-cake.	Poppy-cake.	Cotton-cake.
Water	12·44	10·68	11·63	11·19
Oil	12·79	11·10	5·75	9·08
Albuminous compounds	27·69	29·53	31·46	25·16
Ash	6·13	7·79	12·98	5·64
Other constituents	40·95	40·90	38·18	48·93
	100·00	100·00	100·00	100·00
Nitrogen	4·33	4·38	4·94	3·95
Phosphates	2·73	3·87	6·93	2·19
Phosphoric acid	0·55	0·39	3·27	0·15
Silica (sand)	1·05	1·18	3·36	1·32

* Extracted from the *Transactions of the Highland Ag. Soc.*, 1855, pp. 159, 728, by Dr. Anderson. † Ditto, ditto, 1853, p. 510.

From the above table, it will be seen that the flesh-forming properties of rape-cake exceed those of linseed by 1·84 per cent.; and the fat-forming properties of linseed exceed those of rape by 1·69 per cent.; while the phosphates and phosphoric acid of rape-seed exceed those of linseed by 0·98 per cent.: hence one of the reasons for its value as a manure.

Having now treated of the composition and relative values of the different descriptions of oil-cakes, the following hints upon their use may not be uninstructive.

The value of linseed-cake for feeding cattle is too well established to need further comment; but it should be remarked that the fat of beasts fattened upon it is, after being cooked, of a loose, flabby texture, and not calculated for persons of a gross habit of body. I have, in more cases than one, seen *linseed jelly* used in feeding, and consider it infinitely superior; and, when mixed with a due proportion of hay or meal, it affords an excellent composition for stall-feeding and fattening. There are several methods of preparing it; but the one most generally approved is the following:—To seven parts of water add one part of linseed; let it stand for 48 hours, and then boil it slowly for two hours, stirring it during the time to prevent burning. After boiling, it should be poured out into tubs too cool, and mixed with meal, bran, or cut chaff. An eminent Leicestershire grazier informs me that he has long been in the habit of using linseed prepared in this way, and that it is his practice to give two quarts of the jelly to every large bullock daily; which proportion amounts to little more than half a pint of seed per day, and produces a great saving in the article of food. There can be no doubt that linseed-jelly is more agreeable to cattle than cake, while it is

also less liable to cause surfeit in case an extra quantity should be heedlessly given; and further, it is less liable to affect the meat with a peculiar taste than cake. These advantages render linseed-jelly well deserving of extensive use, especially as it is much cheaper than cake: inasmuch as a ton of English-made cake will cost from £10 to £12, having the greater part of the fattening properties of the seed squeezed out of it, while a ton of the seed itself may be purchased for about £15 to £16, containing all its valuable constituents entire. Moreover, the farmer is liable to meet with adulteration in many shapes in the purchase of cake, the extent of which he has no means of detecting on the spur of the moment; while, in the case of the seed itself, if he purchases an inferior or a dirty article, he does so with his eyes open.

In addition to the valuable feeding properties of linseed and oil-cake, the manure, as before observed, is greatly benefited by the practice. It has been found that every load of hay, chaff, or dry cut-stuff given to beasts fattening on oil-cake yields *seven* loads of dung of *one ton and a half* each, exclusively of the weight of the cake; and, on comparing the dung obtained through feeding with oil-cake with that of the common farmyard, it has been proved that, by spreading twelve loads of the former on an acre, it yields considerably more produce than double the quantity of the latter.

PULPED FOOD FOR CATTLE.

The value of pulped food, in comparison with whole roots, for cattle, is a subject upon which much difference of opinion exists amongst practical men; and I am free

to confess that I have not sufficient practical knowledge to justify me in offering a decided opinion upon th matter: the few observations I have to offer will, therefore, be taken for just what they are worth.

Whatever value attaches to pulped food can arise from no other source than that food in that state does not require so much mastication as is necessary in a raw state; it is taken in by the animal in a state easier of assimilation in the stomach, seeing that, being finely-divided, it is more easily acted upon by the gastric juice, and is therefore more readily transmitted through the first stage of assimilation towards blood; for it must be borne in mind that food of every description must be first converted into blood before it can either feed or fatten. There is no description of food, however rich or nutritious may be its qualities, that can be beneficial to the animal frame, unless it easily submits to the solvent powers of the gastric juices given out by the secretive coat of the stomach. The object of this juice is to render it thoroughly soft, pulpy, or semi-fluid; in this state it is passed onward into what is called the duodenum, or second stomach; here it meets with the bile secreted by the liver, and also other juices secreted by the pancreas or sweetbread; and on these becoming mixed, the whole is converted into a highly-azotized semi-fluid, which physiologists call chyle, a substance which is nearly, but not quite, blood. In this state it passes on into the large intestines, which are furnished with myriads of little mouths, called "chyleous absorbents;" the office of these is to attack the food presented to them on all sides, and to suck or absorb out of it all its nutritive and fattening properties, or at least such portions of these as may come in contact with them. From the

larger intestines the food passes on to the smaller intestines, and these again, being furnished with similar mouths, that portion of the feeding properties of the food which has escaped their attack in the larger intestines, is here compressed into a smaller substance, and subjected to a second attack, till everything valuable, capable of absorption, is sucked out of it. The refuse is then passed onward, and eventually evacuated.

This chyle, obtained as described, is carried along a series of tubes called "chyle-ducts," leading to the lungs; I have before observed that this fluid is very nearly, but not quite blood. On its presentation to the lungs, it meets with the oxygen in the air inhaled by the animal; here it undergoes its last chemical change. By this action it receives its colouring property, and assumes that bright vermilion hue which characterizes arterial blood. Here, so far as we know, it arrives at perfection, attains its vitality, and becomes *life itself.* In this state it is presented to the heart, which consists of two cavities, or "ventricles" as they are called. The action of these may be likened to that of a blacksmith's pair of double-action bellows turned edgeways: as one cavity fills, the other empties; this is owing to the muscles of the heart possessing the power of contraction and expansion, which is called its "contractile" power. No sooner, then, is what we may call the inlet cavity, or right ventricle, filled from the lungs, than it contracts and forces it into the outlet cavity, or left ventricle. The valve through which it is forced being, as is supposed, endowed with a peculiar kind of sensibility, closes as soon as the outlet cavity is filled; that cavity then contracts, and forces the blood forward into the aorta, or great artery, which rises immediately out of the

left ventricle of the heart. This great artery forms the centre from which numerous other arteries of smaller dimensions take their rise; and these extend throughout the whole animal frame, growing "small by degrees, and beautifully less" as they extend, until at length they envelop the whole animal structure, in a beautiful network of minute arteries, by which the blood is conveyed to every part, to strengthen, sustain, and supply to the body those substances necessary to replace the waste caused by exertion, and to build up the structure of the animal during growth.

Now, every species of exertion has a tendency to wear away and destroy some portion of the animal structure, and the portion so displaced can only be renewed by the blood. From this, therefore, it becomes clearly evident that the more finely divided the food when taken into the stomach, the more rapidly it becomes elaborated into chyme, chyle, and eventually blood itself, and the less will be the exertion required from the animal in mastication, and the less also will be the loss sustained through such exertion. Further, the more finely divided the food when taken into the stomach, the more finely divided will it pass into the duodenum, or second stomach, and the more easily will its nutritive properties be taken up by the chyleous absorbents.

Who has not observed, that when a horse has been fed upon unbruised barley or oats, those seeds appear in the dung in a whole and entire state. Such portions of the grain must, undoubtedly, have passed through the animal without benefit, and may therefore be considered as so much food thrown away. Had they been given in the shape of meal, or in a bruised state, their nutritive *properties* would have been taken up, and the animal

proportionably benefited. So with other descriptions of food; and for these reasons I am inclined to the opinion that pulped and ground or bruised food must be greatly superior to that taken in its raw or unground state. Such is my theoretical view of the subject; but, as I have before observed, I have no practical experience to support it; therefore, although it appears to me to be a common-sense conclusion, it must only be taken for what it is worth.

As I consider the subject to be somewhat important, I subjoin the results of two experiments made with pulped food, in order to test it in comparison with whole roots, in feeding cattle. The first of these was made by Mr. Fordham, of Newbury, who thus describes it: "In order to test the method accurately, I purchased, last autumn, two three-year old North Devons, at a fair in my neighbourhood, for £14 apiece. They were not in good store condition. I turned them into a cattle-yard by themselves, and on the 3rd of December placed them with the store-cattle, upon 2 bushels of cut oat-straw and 1 bushel of pulped swedes, 45 lbs. weight, pulped twenty hours in advance, to ferment previous to feeding. I continued this food until the 13th of January, when they were put upon the fattening food; 2 bushels of pulped mangold wurzel, mixed with one of straw, and in addition 3 lbs. of barley-meal per day, until the 28th of April, fifteen weeks, when they were sold. In the course of the day the fattening beasts are well dressed with a dandy brush, a most essential thing to the animals' happiness. It removes dust, circulates the blood, and tends greatly to familiarize them to their attendants, the whole being kept particularly clean, removing the droppings whenever the herdsman enters.

The cattle are fed thus, as soon after 6 o'clock A.M. as the herdsman can attend to it. Mixture of straw, chaff, and pulp roots. The three bushels are divided into five parts—they eat their food better.

9 o'clock	A.M.	....	Mixture.
11·15 „	„	....	Straw, chaff, and 3 lbs. barley-meal.
1 „	P.M.	....	Mixture.
4 „	„	....	Mixture.
5 „	„	....	Mixture.
6 „	„	....	Straw chaff; clean wheat-straw well bedded, to pick over the last thing at night. All looked at.

"The two North Devons consumed, from 3rd December to 13th January, with 7 lbs. each, equal to 14 lbs. cut straw—

	Tons.	cwt.	qrs.	lbs.	£.	s.	d.
42 days, 90 lbs. of swedes..........	1	13	3	0			
40 days, 180 lbs. mangold wurzel ..	3	4	1	4			
65 days, 160 lbs. „ „ ..	4	12	3	12			
At 7*s.* per ton	9	10	3	16	3	7	0
3 sacks of barley-meal at 16*s.* 3*d.*, 105 days at 3 lbs. each					2	8	9
Attendance						14	0
					£6	9	9
First cost £14 each					28	0	0
					£34	9	9

MEASURED FOR WEIGHT.

3rd December.	ft.	in.	Stones.	28th April	ft.	in.	Stones.
No. 1. Length ..	4	7	59	Length	5	1	85½
„ Girth....	5	11		Girth	6	4	
No. 2. Length ..	4	8	70	Length	5	4	94½
„ Girth....	6	0		Girth	6	6	
			129				180

The two beasts sold for £40."

The other experiment alluded to was made by Mr.

M'Laren, farm-manager to Lord Kinnaird. This experiment appears to have been very fairly conducted, and is of a more satisfactory character by far than the former one. The cattle under treatment were eighteen in number, and were divided into three distinct lots. The first lot were fed on whole turnips and straw; the second, on pulped turnips, mixed with chaff, and given fresh; and the third, on pulped turnips mixed with chaff, and fermented. The experiment commenced on the 18th of October and ended on the 1st of March following, being a period of nineteen weeks; at the expiration of the time stated, the respective weights gained stood as follows:—

	cwt.	lbs.
Lot 1. Fed on whole turnips and straw, increased in live weight	11	53
Lot 2. Fed on pulped turnips mixed with chaff and given fresh, gained in live weight	10	56
Lot 3. Fed on pulped turnips mixed with chaff and fermented for 24 hours, increased	12	14

CONSUMPTION.

Lot 1. Consumed 55 tons 11 cwt. 8 lbs. of turnips, with a steamed mess consisting of chaff mixed with 2 lbs. of bean-meal, 2 lbs. of linseed-meal, and ½ lb. of treacle for each beast daily,* costing for the whole 19 weeks the sum of £11. 15*s*. 1½*d*.

Lot 2. Consumed 50 tons 16 cwt. 10 lbs. of turnips during the same period, and the same value of steamed food; but to this has to be added the charge of £4. 10*s*. as the cost of pulping and chaff-cutting.

Lot 3. Fed on pulped turnips fermented with chaff, consumed exactly the same quantity of turnips as the previous lot,

* The treacle, bean and linseed meal, were first mixed with as much hot water as would sufficiently moisten the chaff, the whole being placed in a steam chest along with any refuse of cabbage or turnip-tops, and strongly steamed the day previous to being used.

and they, like the others, consumed £11. 15*s.* 1½*d.* worth of steamed mess; this also, as in case No. 2, is subject to an addition of £4. 10*s.* as the cost of pulping and preparation.

These are the facts contained in Mr. M'Laren's report, simplified, so as to be readily understood, the report itself being presented in a somewhat confused form. The practical conclusions to be drawn from it are the following, viz.:—

	£.	*s.*	*d.*
Lot 1. Cost in feeding (taking the value of turnips at 7*s.* per ton, and throwing aside fractions)			
Turnips, 55 tons 11 cwt. 8 lbs. at 7*s.*	19	9	10½
Steamed mess, &c.	11	15	1½
As the cost of 11 cwt. 53 lbs. of increased live weight	31	5	0
Lot 2. Cost in feeding:—			
Turnips 50 tons 16 cwt. 10 lbs. at 7*s.*	17	15	8
Steamed mess, &c.	11	15	1½
Cost of pulping, &c.	4	10	0
As the cost of 10 cwt. 56 lbs. of increased live weight	34	0	9½
Lot 3. Cost in feeding precisely the same as Lot 2; the only difference being that in Lot 2 the pulped food was given fresh, and in Lot 3 it was given after standing to ferment for the space of 24 hours. Therefore cost of feeding and attendant labour	34	0	9½

For an increased live weight of 12 cwt. 14 lbs.

The foregoing facts justify the following deductions, all other things being equal, viz.:—

Whole turnips and straw are superior to pulped turnips and chaff in a fresh state, in the following ratio; *i. e.* the raw food (Lot No. 1) cost £31. 5*s.*, and produced 11 cwt. 53 lbs., or 1,285 lbs. of meat. The *fresh* pulped food cost £34. 0*s.* 9½*d.* and produced only 10 cwt. 56 lbs.,

or 1,176 lbs., whereas it ought to have produced, to make it equal to No. 1, 1,399 lbs.; but as it produced only 1,176 lbs., there is clearly a loss upon using fresh pulped food when compared with whole roots and chaff, to the extent of 223 lbs. of meat, which, if we estimate it at 6*d.* per lb., will amount to the sum of £5. 11*s.* 6*d.* Fresh pulped food is therefore clearly out of the question as to its feeding qualities.

In the case of No. 3, where *fermented* pulped food was used, the cost being precisely the same as in Lot 2, the fermented food gave 1,358 lbs. of meat, when, to make it equal to Lot No. 1, it ought to have been 1,399 lbs.; the loss in this case being 41 lbs., which, estimated at 6*d.* per lb., as before, will amount to £1. 0*s.* 6*d.* It would appear, however, that the foregoing experiments were not satisfactory to Mr. M'Laren, and he therefore commenced a second series of experiments upon the same number and same kind of animals, only selecting them one year younger than the former. This experiment was commenced on the 8th of November, 1856, and concluded on the 9th of April, 1857:—

	Weighed. Nov. 8, 1856.		Apr. 9, 1857.	
	cwt.	lbs.	cwt.	lbs.
Lot 1. Six beasts fed on whole turnips and straw	54	54	75	0
Lot 2. Do. do. fed on pulped turnips given fresh mixed with chaff, &c.	54	68	79	28
Lot 3. Do. do. fed on pulped turnips mixed with chaff, &c. and fermented	54	28	78	7

After calculating the difference in cost of the respective food given to each lot, and making all necessary deductions on account of labour, &c., Mr. M'Laren found the profit from feeding these different lots in 1856-7 to be as follows:—

	£.	s.	d.
Lot 1	15	17	4
„ 2	23	15	10
„ 3	22	14	4

In noticing these experiments, the Journal of the Transactions of the Highland Society contains the following comments:—"That although there has been some variation as to the largest increment this season, it being on the lot consuming unfermented pulp, whilst last year these were much in arrear, still the general result has been that the pulping of turnips is a saving of the root in feeding cattle. At the same time it is not to be forgotten that, in a feeding experiment, much depends on the accident of a well or an ill-feeding beast being in one or other of the lots. It is, indeed, almost impossible to find any two animals feed alike, however well selected or attentively looked after; still, the average of six cattle in each lot should give a pretty fair test to judge by; but one set of trials can hardly be held to be conclusive in determining either success or failure of any system."—(*T. H. S.* 1858, p. 153.)

COOKED FOOD FOR CATTLE.

Whatever may be the comparative merits of pulped and whole roots, there can be no doubt with respect to the advantage of feeding stock upon cooked, or partially cooked food, in preference to giving it to them in its raw state. Animals were unquestionably designed by nature to eat their food raw, that is, while living in a wild state; but, I greatly doubt whether nature ever contemplated the contingency of their existing in the very artificial state which modern science requires them to

submit to, or ever contemplated that a period should arrive when from sixteen to twenty weeks would be found sufficient to convert a lean beast into a fat one. That such is now the case, however, the experiments contained in the preceding chapter are sufficient to show.

The great object in cattle-feeding, as it appears to me, is to get as much solid food into the stomach of the animal as the gastric juices supplied by the secretory coat of the stomach is capable of readily converting into blood, and to reduce as much as possible the time required for mastication. Nature was evidently aware, when she first formed the ox and the sheep, that, from the peculiar construction of their teeth and jaws, and the character of the food destined for their use, the latter would be difficult of assimilation; hence she supplied them with a second stomach, so that, during the time for feeding, their food might be taken in large quantity into the first stomach, and there retained in a partially masticated state, until the animal had taken quite sufficient for its purposes; and that, when in a state of rest, this could be returned to the mouth to undergo a second process of mastication, so as to thoroughly disintegrate it, and in this state present it to the second stomach, where it could be operated upon by the gastric juices there poured out upon it, and be thus forwarded a step onward in its process of assimilation.

I am always happy to quote Mr. Alderman Mechi when I can do so consistently with my own convictions; and I boldly assert, although sophistry may evade and bigotry deny the fact, that Mr. Alderman Mechi has done more than any one man of the present age in improving the practice of farming. I therefore hail with delight, from so eminently practical an au-

thority, the following views and sentiments enunciated by him:*

"Were we to treat our bullocks and our sheep as we do ourselves and our riding-horses,—keep them clean, warm, dry, and well fed, we should increase strangely the quantity and quality of our animal food.

"Let us imagine ourselves standing or lying day and night for months in the moisture and effluvia of our own accumulated excrements, uncleaned and ill-fed: it won't bear thinking of; and yet this is how most farmers treat their cattle. Their food is presented to them in large unmanageable masses, with abundance of dirt (a corrector of acid it is called), uncooked and unprepared. We need not wonder at having to stab our bullocks to let out the accumulation of windy flatulence, or forcing strange-looking machines down their throats to remove solid lumps of unmasticated roots. We need not wonder at foot-rot, fevered feet, and other complaints. The idea of a man swallowing a quantity of frozen turnips on a frosty day, without a bit of bread, absorbent, or stimulant of any kind!!! It is too ridiculous to think of.

"I will lay it down as an indisputable fact, as proved by our greatest breeders of animals, that we must apply to them the same treatment as we would to ourselves, if we wish to render them profitable. It is high time we amended our absurdities in this respect, or we shall have Spain, Portugal, or other warm and genial climes, stocking us with what we ought to produce ourselves."†

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* *How to Farm profitably*, p. 45.

† The importation of foreign cattle is increasing more rapidly than farmers may be apt to imagine. From official returns I find that the import of animals living,—namely, oxen, bulls, and cows, in the year 1844, was 1,237, while the number imported in 1859 amounted to

Without indulging further in matters of a purely speculative character, I proceed to lay before my readers a few of the results collected from the reports of some of our most eminent agriculturists in differents parts of the country. And as these experiments were made at different times, under different circumstances, with different descriptions of cattle, and in different parts of the country, they are entitled to be considered as conclusive as to the merits or demerits of the practice. The following is the result of an experiment made by Mr. HUTTON,* of Sowberhill, near Northallerton, Yorkshire:—

"In the first week in April, 1845," says Mr. Hutton, "I put up 60 head of cattle on prepared food, and found the plan to answer remarkably well; of these, about 20 were in a very forward state, and they were allowed to have prepared food at the rate of *5s. 3d.* per head per week. They made great improvement, and were sold on the 9th July, several of them fetching £20 each."

The following is a specification of the food, and the cost of preparing it, as furnished by Mr. Hutton:—

FOR ONE BEAST PER WEEK.	£.	s.	d.
13 lbs. of linseed, bruised, or 2 lbs. per day for six days, and 1 lb. for Sunday	0	1	9
32½ lbs. of ground corn, or 5 lbs. per day for six days, and 2½ lbs. for Sunday, at 1*d.* per lb.	0	2	8
35 lbs. of Swede turnips, given twice a day, and thrice on Sunday	0	1	6
Coals, 1½*d.*; labour on each beast, 6*d.*	0	0	7½
Total expense of each beast	0	6	6½

62,018; and that the importation of other descriptions of live cattle had increased in like proportions.

* Mr. Hutton occupies about 1,500 acres of land, and is a noted stock-feeder.

In order to test the comparative value of giving cooked food to cattle in preference to raw, Mr. Hutton put up two lots of cattle, feeding them for eight weeks, the one lot with oil-cake, turnip, and straw; the other lot with linseed cooked, ground grain, cut-straw, and turnip. "The latter lot," he observes, "cost the least to feed, and paid the best when sold." And he further remarks that he approves of the cooked food plan for stall-fed, store, dairy, or young cattle—regulating the supply and quality according to each class. It answers also equally well for horses and sheep; and in conclusion he says:— "What I have seen of this system convinces me that certainly *double the quantity of stock* can be maintained with the same quantity of turnips as was consumed by the old method of feeding cattle. The manure is of the best quality, and very soon fit for use. No manure I have seen has equalled in efficacy that derived from this process. Hence it is hard to fix any precise limits to the number of stock that may be maintained on a farm with a moderate supply of turnips, when this method is rightly carried out and persevered in."

Mr. H. S. Thompson, of Moat Hall, near York, states that, having found his previous system, viz., that of feeding upon oil-cake instead of linseed cooked food, to work well, "I determined to give it a fair chance against the new one; and I accordingly selected two of the most thriving of a lot of 12 bullocks, of nearly the same age and condition, and fed them for the first month on the food I had been in the habit of giving; viz., swede turnip, linseed-cake, and bean-meal, in the proportions stated below. Two others, of nearly equal weight, had their food prepared according to your

(Mr. Marshall's) directions.* All four were weighed at the commencement of the experiment, viz. April 11th, 1846. Their weights are given in table No. 1. The numbers are the numbers of their stalls, to prevent mistakes. Nos. 8 and 9 were fed in the new way; Nos. 12 and 13 in the old. They were weighed a second time on the 15th of May.

TABLE No. 1.

No. of stall.	Live weight, April 11.		Live weight, May 15.		Increase in weight.	
	st.	lbs.	st.	lbs.	st.	lbs.
8	83	8	88	4	4	10
9	79	8	85	1	5	7
12	81	0	85	2	4	2
13	85	0	89	0	4	0

"Thus it will be seen that the bullocks fed on the old plan gained 8 st. 2 lbs. in five weeks; and those fed in the new way gained 10 st. 3 lbs. in the same time. As I was convinced that the two bullocks which had made the least progress were, nevertheless, the most thriving animals, I for the next month fed all four alike, viz., on swedes, mangold wurzel, and your prepared food. The results are as follows:—

TABLE No. 2.

No. of stall.	Live weight, May 15.		Live weight, June 15.		Increase in weight.	
	st.	lbs.	st.	lbs.	st.	lbs.
8	88	4	92	4	4	0
9	85	1	90	12	5	11
12	85	2	92	7	7	5
13	89	0	96	0	7	0

* This letter is extracted from Mr. Marshall's *Prize Essay* on the use of cooked food for cattle, which first appeared in the *Transactions of the Yorkshire Agricultural Society*; the directions alluded to being those given by Mr. Marshall.

"The impression that the bullocks Nos. 12 and 13 were better thrivers than Nos. 8 and 9, was, it will be observed, fully borne out when the four were fed alike, the latter two having made 14 stone 5 lbs. in 31 days, and the former only 9 stone 11 lbs. If we compare the increase of weight of the two bullocks, Nos. 12 and 13, when fed on the old plan for 34 days, viz. 8 stone 2 lbs., with the increase of the same bullocks when fed on your plan for 31 days, viz. 14 stone 5 lbs., the superiority of the method is very apparent. The 12 bullocks mentioned above, were in March taken lean from the straw-yard,—quite unfit, in fact, for tying up to feed, except by way of experiment; yet they made such rapid progress that some of them were sold to the butchers at *7s. 3d.* per stone at the end of May; and the last were sold the third week in June in good killing condition."

I could add many more experiments of this sort, having now before me no less than 103, taken from almost every county in England and Scotland, all bearing witness to the same facts. I shall, however, content myself with one more extract from Mr. Mechi's book, in order to show what may be done on a small farm, with adequate capital well applied. By *adequate capital* I mean certainly not less than £10 per acre, but rather £12 to £15 per acre; for it cannot be too confidently asserted that a farmer will do better with a balance at his banker's, although he may not receive interest for it, than when he is obliged "to live from hand to mouth." Without such a balance, he *must sell* to meet his necessities, whether markets be good or bad; with such a reserve fund, he can bide his time. Besides, if a farmer can pay for his oil-cake, linseed, or manures within a month after delivery, he is sure of a discount of at least 5 per

cent., and upon his wheelwright's and blacksmith's bills, as well as for his implements, at least 10 per cent. It is therefore evident that a sufficient balance at his banker's to meet these contingencies will be of great advantage. In speaking of the farm I have before alluded to, Mr. Mechi states (p. 82):—

"To me the most interesting operation was the management of a small off-hand farm of 52 acres.* It is an example worthy to be followed, where there are small holdings and limited means. It may readily be imagined that in its primitive state it produced neither much meat nor corn. The fields being enlarged and the land drained, I was most agreeably surprised to find 27 bullocks fattening, tied up on boarded floors in what had recently been a barn. There was the necessary accompaniment of a copper for cooking, a corn-bruiser, a turnip-cutter, a chaff-cutter, and a thrashing-machine! Do not be alarmed, gentle reader,—a real thrashing-machine on a 52-acre poor farm. Well there it was, a hand thrashing-machine, by Barrett, Exall, & Co.; but his lordship would not suffer such a barbarism as to make a beast or a steam-engine of mind and matter combined. No; a simple over-shot water-wheel, supplied from the hill, gave power and velocity to all the machines I have described; and at what cost, think you? —about £63 for the whole. I buttoned up my coat and felt resolved that old England could and should feed her own population; ay, and employ them too. But where is the food for 27 bullocks? All provided, now and *in futuro*. Plenty of oats, of turnips, of tares on the wheat-stubble, of clover, and 4 acres of nice watered

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* One of Lord Fortescue's, near South Molton.

meadow, available at almost any period of the summer. Plenty of manure in the manure-house, to grow the next root crops. No guano bought—nothing but 2 cwt. of superphosphate of lime, and the home-made manure. Oh! it was a delightful sight, and a beautiful landscape.——But let us leave off the enthusiastic for the practical. Here were the elements of compound fertility and reproduction:—The produce of the farm is to be beef, pork, and wheat; depend upon it, if the animals do not pay (which I do not admit), they leave us a legacy, without which, as farmers, we cannot succeed.

"'Oh! but,' says some lynx-eyed critic, 'where are your horses, Mr. Mechi?' Ay, where are the horses? Why, I am happy to say, nowhere on this 52-acre farm; but I saw a pair of young Devon bullocks (capital beef they will make some day) ploughing deep and well an acre per day. These are the horses; they take their place and food beside the other bullocks. In fact, one of the most pleasing symptoms of my visit was not to find a horse (excepting three or four condemned ones) on his lordship's great farm."

In conclusion, I may observe that so obvious are the advantages of cooked food, that its use is now gradually and steadily becoming the rule instead of the exception. Yet many there are who even now object to it, on account of the extra trouble it causes, and the trifling outlay requisite for the necessary apparatus. With men of this class,—and, alas! they are but too numerous,—there is nothing for it but first to raise their rent, and if no improvement should then take place, to turn them out at once; they are utterly incapable and unworthy to farm,—they are past cure.

OVERFEEDING CATTLE.

The subject of overfeeding cattle has lately been brought somewhat prominently before the public, by Mr. Grant, surgeon to the Royal Free Hospital, London. His observations arose from what he saw of the prize-cattle slaughtered in the butchers' shops after the Smithfield cattle-show in 1858. He observes that overfeeding, especially laying on fat to the extent which is now practised, has a tendency to produce disease: "Were a man in this condition to present himself to an insurance office, it would refuse to insure his life at any premium. Yet, under similar circumstances, a sheep is awarded gold and silver medals, and its feeder a prize of £20. Under the present system, the public are not insured the best, if, indeed, the cheapest food. The bulky withers of a fat bullock are no criterion of health; for his fat tabular back may conceal the ravages of disease. All this can alone be disclosed by inspection after death. The flesh of animals which has been produced by organs themselves diseased, is itself also necessarily deteriorated, and ought not to be regarded as prime samples of human food."

In reply to all this, I am quite prepared to admit that overfeeding has a *tendency* to produce disease, and to shorten the duration of life; that an insurance office would be therefore perfectly right in declining a proposal from an habitual gourmand, as much so as from an habitual drunkard; and, if a farmer's object in fattening his cattle up to a high degree were simply to cause longevity, I should say Dr. Grant's observations would be perfectly applicable; or, even supposing that it was intended to continue the fattening process for as many

months as it is now practised for weeks, I should still say the argument was a sound one: but this is not so. The period of fattening is generally confined to a period of about four or five months; and if either the lungs or the digestive organs of the animal were diseased, it would not take on fat at all; it is, therefore, perfectly clear that the beast must be in good health when the fattening process commences. A constitutional disease, such, in fact, as could deteriorate the quality of the food, must arise from an impurity of the blood, and this would lead to inflammation, and most likely end in fever; and either of these, even in an incipient state, would be sufficient to prevent the process of laying on fat. On the other hand, if by overfeeding such a high degree of temperature be produced in the venous blood of the animal, inflammation of the lungs might ensue, and that again would indeed effectually prevent the laying on of fat, by causing the death of the animal, particularly if the overfeeding process were persisted in. If, again, the lungs of the animal were diseased before the fattening process commenced, that would induce consumption; and whoever heard of a consumptive man or animal ever getting fat! But, it may be objected that the disease may arise from the fatty degeneration of the heart. Granted again: nothing is more common in a fattened beast. But fat always accumulates on the outside, and not in the inside of that organ, and it is with the inside we have to do. The accumulation of fat round and about the heart has undoubtedly a tendency to obstruct its power of expansion and contraction to a considerable extent; in fact we know this must be so, otherwise the fattened animal would be just as lively as the lean one, whereas it is always more sleepy and in-

dolent. But this is no criterion by which we can come to the conclusion that the flesh of the animal is deteriorated in quality for human food; and I have yet to learn the difference, chemically, between this fatty matter formed round the heart and cod-liver oil, so strongly recommended by the faculty. Verily, Mr. Grant, the dilemma has many horns, and the next time you wish to frighten the public out of prize-cattle-show meat, you should begin with something better than begging the question.

Still I think there may be useful matter for reflection in Mr. Grant's remarks, in so far as they may induce stock-feeders to adapt experiments to determine the respective fitness of different breeds of stock to take on fat; and it might be worth while to see also to what extent this could be done without injury to either the animal, farmer, or consumer.

COMPARATIVE VALUE OF FODDER CROPS.

The subjoined table of the comparative value of fodder crops cannot prove otherwise than useful, as it will enable the farmer at once to determine the amount of fat-forming and flesh-forming compounds contained in each particular article of food; and will, therefore, furnish a good criterion for him to go by. I have several tables of this sort before me, but prefer the one published by Professor Johnson as the most simple and comprehensive. It will be remembered that the husk or woody fibre is indigestible, and, therefore, nearly valueless—except for such phosphoric acid as it may contain, useful in furnishing bone; and that the starch, gum, and sugar indicate the *fat-forming* properties, and the gluten, albumen, and caseine the *flesh-forming* properties of the food.

A TABLE OF THE COMPARATIVE VALUE OF FODDER CROPS.

100 parts of	Water.	Husk or Woody Fibre.	Starch, Gum, and Sugar.	Gluten, Albumen, and Caseine.	Fatty matter.	Saline matter.
Field beans	16·0	10·0	40·0	28·0	2·0	3·0
Peas	13·0	8·0	50·0	24·6	2·8	2·8
Barley	15·0	15·0	60·0	12·0	2·5	2·0
Oats	16·0	20·0	50·0	14·5	5·6	3·5
Meadow hay	14·0	30·0	40·0	7·1	2 to 5	5 to 10
Clover hay	14·0	25·0	40·0	9·3	3·0	9·0
Potatoes	75·0	5·0	12·0	2·25	0·3	0·8 to 1·0
Carrots	85·0	3·0	10·0	2·0	0·4	1·0
Turnips	85·0	3·0	10·0	1·2	—	0·8 to 1·0
Oat straw	12·0	45·0	35·0	1·3	0·8	6·0
Wheat straw	12 to 15	50·0	30·0	1·3	0·5	5·0

Upon grinding, 14 lbs. of good wheat ought to yield, on the average, 13 lbs. of flour; the same quantity of barley, 12 lbs.; and of oats, only 8 lbs.

THE USE OF SALT IN FEEDING CATTLE.

The value of salt in feeding cattle has long been known, and it is somewhat strange that its use is not more general. Salt not only contributes to the health of cattle and sheep, but accelerates their fattening, and promotes the quantity of milk given by cows. It prevents the rot in sheep, and the effect of *hoving* when stock are fed on turnips and clover. I have before observed that salt renders damaged hay more palatable and nutritious; and if applied in difficult seasons, prevents an undue heat and fermentation in the stack. By its use, chaff and straw too are rendered more valuable for feeding purposes; and it has been found of the greatest value in preparing cooked food for cattle.

Mr. Curwen states, "I have long been in the habit of using salt as a medicine for cattle; and from my experience of its salutary effects, I consider it one of the most useful condiments ever used."

The following testimony to the value of salt in feeding sheep was given by Lord Somerville before a Committee of the House of Commons upon the salt-duty. His lordship stated: "In the spring of 1801 I brought to England 200 Merino sheep, which I purchased in Spain for about £4,500; and as these sheep had been accustomed to the constant use of salt in Spain, I thought that in our damp climate, and in the rich deep vale of Taunton, where I kept them, it would be absolutely necessary to supply them with salt. I continued to give

salt regularly to these Merino sheep, and gradually to all my other sheep, from 1801 to 1808.* When I let my land in Somersetshire, I purchased a place in Surrey, on a sandy soil, on which I continued to reside until 1815. On this light dry land I did not think it necessary to go to so large an expense for salt, and I therefore discontinued its use; but for some years I lost many of my young sheep, which I am inclined to think might have been saved had I continued as before to give them salt. I have since purchased a place in Sussex, on a clay soil; have again resorted to the practice of giving salt to all my sheep, which I consider absolutely essential to their health. And I may say, that from the practice of several years, I consider the advantages of salt for sheep, and for preserving hay, and restoring it when damaged, as practically established beyond controversy." His lordship further observes: "I think that sheep would require rather more salt in spring and autumn, when the dews are heavy, than in other parts of the year. In the dry climate of Spain they consume, for 1,000 sheep, in five months, only 128 lbs. of salt. But more is required in our climate, and still more on some particular soils. I use at the rate of a ton of salt for every 1,000 sheep annually, and give it them in the morning, to counteract the ill effect of the dew. A small handful is put on a flat stone, tile, or slate; and ten or fifteen of these, set a few yards apart, are enough for 100 sheep. At first the sheep may be moved towards them: if they feel a craving for salt, they will lick up

* At the period of which I am writing, the duty upon salt was 15s. per bushel of 56 lbs., or £30 per ton, and large fortunes were made by having it weighed and the duty charged at the works, in consequence of the large amount of moisture it imbibed afterwards.

quickly as much as is necessary: twice a week has been usually found sufficient; in particular cases it may be offered thrice. Of a flock of near 1,000 there were not ten old sheep that did not take to it kindly, and not one lamb that did not consume it greedily. When turnips in the early season are stocked with sheep, and the greens are rank and strong, many die suddenly, more especially young *two-toothed sheep*. The disorder is pent-up wind, occasioned by excess of fermentation in the stomach; in which case *salted* hay and salt are devoured by them with a greediness that denotes their salutary effect. And though the autumn of last year was rainy and unfavourable, I did not lose one sheep on turnips. And for rot I consider salt as a specific, except on land naturally unsound; and even there the disease is much diminished by the use of salt."

The late J. C. Curwen, Esq., M.P.,* observes: "I give my cows 4 oz. of salt each daily; young and fattening cattle, 3 oz.; working oxen, 4 oz.; three-year olds, 2 oz.; calves, 1 oz.; working horses, 4 oz.; and sheep, 2 oz. each per week, given at twice, on slates."

Though the foregoing observations date from the early part of the present century, they contain abundant matter for reflection; and if read in connection with the remarks made upon "the use of salt as a manure," and acted upon as common sense dictates, I feel convinced that useful results may reasonably be anticipated. We have seen with what avidity sheep consume salt; and we know that when turned into a partly salted pasture they prefer the salted portions. We also know that

* Author of *Hints on Agricultural Subjects, and the Best Means of Improving the Condition of the Labouring Classes.*

horses will eat these portions quite bare before they will touch the unsalted parts. Does not all this tend to show, first, that salt is highly beneficial to animals? and second, that when properly applied, it not only increases the quantity of the crop, but, by checking rankness, imparts to it a more agreeable flavour? Cattle consequently relish it better and thrive more rapidly upon it.

TEMPERATURE, VENTILATION, AND CLEANLINESS.

Without proper attention to these three essentials, it is impossible to feed either cattle, sheep, or pigs to the greatest advantage. In reference to temperature it must be borne in mind, that "warmth and comfort economize food; that shelter for sheep, dry sheds for cattle, warm, yet well-ventilated stables, repay their owner for all his care and outlay." Ventilation also is equally important: to expect an animal to thrive well while breathing an atmosphere strongly charged with ammoniacal and other noxious gases, is absurd. Pure air is as necessary as wholesome food, and, without it, neither the health of the animal, nor its aptitude to lay on flesh and fat, can be maintained. Mr. Mechi has the following observations upon this subject:—"Pigs that lie on horse-dung or heated manure, and then walk in the ordinary air, will almost certainly get "heaves" or lung disease. Non-ventilation, and a putrescent atmosphere, will produce many diseases amongst live-stock, and amongst human beings too." Besides, as Lord Kaimes justly observes, "To keep cattle clean is to them half food." And again Mr. Alderman Mechi very sensibly supplements this assertion by stating, "I have

often been struck on seeing how soon my groom will get a horse into condition by warmth, cleanliness, and food. The same remark applies to a lady's lap-dog. My bullocks are all groomed daily by a boy, whose sole occupation it is. The cost is about a farthing per head per week, and I am sure it pays." "Let us," continues the same author, "keep them warm in winter and cool in summer—free from tormenting flies. In fact, I shall never consider we are perfect till we can keep up a given warmth in winter, whilst we have in summer cool and shaded paved yards."

This is plain practical common sense, and as there are hundreds of farmers who greatly stand in need of the wholesome advice here given them, we hope, for their own sake, that they will lose no time in profiting by it. Innumerable instances might be quoted, where warmth, cleanliness, and ventilation have proved equally important with food; but sufficient has been said to satisfy every reflecting mind, how strictly essential is their observance, to the well-being of all animals, whether intended for food or work. For further particulars upon this important subject, our readers may consult the valuable essay of Mr. W. Wright in the *Journal of the Royal Agricultural Society*, vol. xix. p. 500: it is full of the most useful practical information.

APPENDIX.

APPENDIX.

APPENDIX A.

DIFFERENCE BETWEEN MECHANICAL MIXTURES AND CHEMICAL COMPOUNDS.

"IN a mechanical mixture," says Mr. SIBSON (*Agric. Chem.*, p. 18), "each constituent remains unaltered in its essential characters, and may generally be recognized in the mixture by the naked eye or by a microscope, and in most cases may be removed from the mixture by mechanical means; and further, when separated, will be found in the same condition as it was before being added. The appearance and external properties of a mixture are regulated by those of its constituents. On the contrary, in a chemical combination, or, as it is called, a compound, one substance at least is essentially altered, and by no amount of examination by the naked eye or by the microscope, can the constituent particles be detected. Hence the smallest particle is of the same quality as the bulk of the substance, the whole being perfectly uniform and homogeneous. Moreover, the qualities of compounds are not regulated by those of their constituents. Liquids may produce solids;—gases may produce liquids;—poisons may be formed from innoxious substances; so that no opinion can be formed of the characters of a compound by judging of the qualities of its constituents. A few examples will render this more intelligible.—When chalk is powdered and mixed with water, a creamy liquid results, possessing qualities intermediate between those of chalk and water. On standing, the chalk settles to the bottom, and the clear water is the same as before the experiment. If, instead of chalk, we use plaster of Paris, the creamy liquid, in this case, will quickly harden, and finally become a solid mass; the water will disappear and no longer be perceptible by the properties it exhibits in a liquid form. In this latter case, the materials employed have combined together chemically. Again, gunpowder is a mechanical mixture, although a most intimate one. It consists of charcoal, brimstone, and saltpetre. By washing in water, the nitre is dissolved, and now can be easily removed and separated

from the other two ingredients by filtering and straining. The nitre may be obtained in a solid form by evaporating or boiling away the clear liquid over a lamp or fire until it dries up. The two other constituents may also be separated by suitable means, not necessary to describe here. Each constituent thus separated from gunpowder will be found in precisely the same condition as regards its chemical characters, as before being manufactured. But all know that if fire be applied to gunpowder, it is instantly consumed, leaving nothing but a small residue; in other words, its constituents have combined chemically—and how different are the resulting compounds. Except a trace of solid matter, nothing but smoke is seen; yet these compounds, with some invisible gases, contain all the sulphur, charcoal, and nitre that existed in the gunpowder. These materials have assumed new forms, in which none of their original properties can be recognized.

"Another extraordinary property of chemical compounds is, that they always contain definite proportions of their constituents; from whatever source derived, they are invariably of the same composition, and possess the same chemical characters. For instance, chalk is a compound known as the carbonate of lime: it is found to be precisely the same material, whether obtained from chalk rocks, or prepared by passing carbonic acid into lime-water. In both cases the chalk is chemically identical, and consists of 22 parts of carbonic acid and 28 parts of lime.

"It has been wisely ordered that oxygen and nitrogen in the air shall only be mechanically mixed, not chemically combined. Had it been otherwise, or were they suddenly to combine, the whole face of nature would be altered; the bland health-giving air would be changed into nitric acid, or aqua fortis. The only essential difference between the air we breathe, and aqua fortis is, that in the air the above gases are simply mixed, in the latter case chemically combined."

APPENDIX B.

TO DETECT ADULTERATION IN BONES.

As bone-dust is frequently, and also easily adulterated, I give the following method for its detection as the simplest with which I am acquainted: 1st. Take a fair sample, say 1 oz. out of the centre of the

bulk; dry it upon a plate in a slow oven, at a temperature not exceeding 250°. After this process, it should lose, when thoroughly burnt in a common iron or brass ladle over a strong fire till quite white, about one-third of its weight, which is the organic substance of the bone. The burnt mass should be scarcely soluble in water, but dissolve with very little residue in boiling dilute hydrochloric acid (spirit of salts). This for practical purposes is sufficient; as, if adulterated with either gypsum, chalk, sand, or salt, the weight of the ash will be greater in proportion to the extent of adulteration.

We will, however, pursue the process of this analysis a step further, for the benefit of the rising generation of farmers, who may perhaps wish to learn how to analyze bone-dust. Having boiled the ash in dilute hydrochloric acid, as before directed, filter the solution (which may be done in a common glass funnel with a little cotton-wool at the bottom), and when so filtered, add liquid ammonia (the best of that procurable at the shops will do): this will cause a precipitate to fall. This must be well washed by pouring rain-water upon it very gradually while upon the filter; after this, it should be first dried on a small plate in the oven, at about 250°, and then burnt as before directed. In weight it should not be less than two-thirds of the *burnt bone:* it consists of phosphates of lime and magnesia. The substances likely to be employed in the adulteration of bone-dust, being those before mentioned, they will all be detected by this process. To attempt an estimate of the relative amounts of phosphates of lime and magnesia would involve a series of manipulations far beyond what a tyro in chemistry could perform, and therefore instructions upon that head would be useless here.

APPENDIX C.

ADVERTISED CATTLE-FOODS.

The trade in *advertised cattle-foods* is assuming dimensions of such magnitude, as to render it necessary that the farmer should be put upon his guard in reference to them. Not that I think farmers are by any means the chief customers of the advertisers; but still (if the published testimonials are to be depended upon) they do purchase these foods to some considerable extent. I have no wish to say "aught in

malice" against them, I simply desire to caution the farmer against being led away by specious advertisements, vague testimonials, and pictorial show-cards. For the most part, these kinds of cattle-food are well put together, and ground remarkably fine, so as to render the detection of their component parts a matter of difficulty. But in so far as their feeding and fattening properties are concerned, they are amenable to the same laws as other descriptions of food, and if we cannot arrive at their precise constituents, we can at all events determine their relative values, with other articles of food of well-known quality, by a comparison of their effects. And as these foods are sold at from 40*s.* to 50*s.* per cwt., they cost about four or five times as much as the most nutritious foods now in use. If we compare them with other well-known articles of food, we shall find, that to repay the farmer money for money, 1 cwt. of these advertised cattle-foods, at 45*s.*, should be equal to about

				s.	*d.*		£.	*s.*	*d.*
5½	cwt. of	barley	at	8	4	......	2	5	10
5	,,	oats	,,	9	2	......	2	5	10
4¾	,,	beans	,,	9	6	......	2	5	1½
4¾	,,	peas	,,	9	8	......	2	5	11
4½	,,	lentils	,,	10	2	......	2	5	9
4½	,,	oil-cake	,,	10	2	......	2	5	9
2¾	,,	linseed	,,	16	6	......	2	5	4½
11½	,,	hay	,,	4	0	......	2	6	0
Cost of 43¼	,,	....					18	5	7
Cost of 8 cwt. of advertised cattle-food, at 45*s.* =							18	0	0

To the latter may be added 5*s.* 7*d.* for carriage. To produce equal results, 8 cwt. of cattle-food must, therefore, make as much flesh, &c. as 43¼ cwt. of the ingredients mentioned in the foregoing table. But do they do so? All the experiments hitherto made, that I am acquainted with, show that the very reverse is the fact, so far as their flesh- and fat-forming properties are concerned. Mr. Lawes instituted some comparative experiments in order to test the value of one of these foods, and for this purpose he chose six pigs as nearly equal in weight as could be obtained. These he divided into two lots of three each, viz.—Lot 1 and lot 2. To lot No. 1 a mixture was given composed of nine parts of barley-meal and one part of bran; to lot No. 2 the same quantity of barley-meal and bran was given, with the addition of two parts of manufactured cattle-food. In each case the food was stirred up with hot

water, and both lots were allowed as much of their respective foods as they chose to eat. The following are the results of the experiment:—

	Lot 1. Nine parts of barley-meal and one part of bran.	Lot 2. Nine parts of barley-meal, one part bran, and two parts of the manufactured cattle-food.
No. of pigs	3	3
Duration of experiment	28 days	28 days
Original weight	357 lbs.	355 lbs.
Final weight	496 „	494 „
Increased weight	139 „	139 „
Total food consumed	547 „	556 „
Food consumed to produce 100 lbs. of increased weight	393 „	400 „

With these facts before us, the comparative cost of the two experiments is easily determined:—

		cwt.	qr.	lbs.			s.	d.		£.	s.	d.
Lot No. 1	consumed	4	1	16	barley-meal	at	8	6	per cwt.	1	17	3
„	„	0	2	0	bran	at	6	6	„	0	3	3
										£2	0	6
Lot No. 2	consumed	3	2	25	barley-meal	at	8	6	per cwt.	1	11	9
„	„	0	1	18	bran	at	6	6	„	0	2	9
„	„	0	3	6	cattle-food	at	42	0	„	1	14	6
										£3	9	0

It will also be seen that the barley-meal and bran given alone produced 139 lbs. of flesh and fat, the cost being £2. 0*s.* 6*d.*, or 3½*d.* per lb.; while, on the other hand, the barley-meal, bran, and manufactured cattle-food, produced the same amount of flesh and fat, at the cost of £3. 9*s.*, or within a fraction of 6*d.* per lb. This experiment alone, derived from so reliable an authority as Mr. Lawes, ought to be considered conclusive as to the true value of these extensively puffed "cattle-foods."

I have been favoured by a friend with the following, as the ordinary formula for making a ton of one of the most extensively advertised of these foods:—

		cwt.	qr.	lbs.	Wholesale cost price. £.	s.	d.
Carob (locust) bean, finely ground	at £6 per ton	6	0	0	1	16	0
Indian corn	at £7 „	9	0	0	3	3	0
Linseed-cake	at £10 „	3	0	0	1	10	0
Powdered turmeric	at 6*d.* per lb.	0	0	40	1	0	0
Sulphur	at 1½*d.* „	0	0	40	0	5	0
Saltpetre	at 4½*d.* „	0	0	20	0	7	6
Liquorice	at 10*d.* „	0	0	27	1	2	6
Ginger	at 6*d.* „	0	0	3	0	1	6
Aniseed	at 8*d.* „	0	0	4	0	2	8
Coriander	at 8*d.* „	0	0	10	0	6	8
Gentian	at 7*d.* „	0	0	10	0	5	10
Cream-tartar	at 1*s.* 3*d.* „	0	0	2	0	2	6
Carbonate soda	at 4*d.* „	0	0	6	0	2	0
Levigated antimony	at 6*d.* „	0	0	6	0	3	0
Common salt	at ¼*d.* „	0	0	30	0	0	8
Peruvian bark	at 3*s.* 0*d.* „	0	0	4	0	12	0
Fenugreek (trefoil) ..	at 7*d.* „	0	0	22	0	12	10
	Total	20	0	0	11	13	8

The above articles are put down at the ordinary wholesale market price, but if purchased in large quantities, might be got much cheaper. The use of the best linseed-cake is also assumed, when it is by no means improbable an inferior description is often used. However, be this as it may, a profit of 200 per cent. ought to afford the use of none but the best articles. Independently of the slight colouring with turmeric and flavouring with liquorice, coriander, aniseed, &c., and the medical compounds as before set forth, the main bulk of these manufactured foods is composed of the carob bean, Indian corn, and linseed-cake. These form nine-tenths of its substance; and it is worthy of note, that of these by far the most valuable, in point of both price and feeding quality, is linseed-cake, and this is used in the smallest proportion. If, however, the farmer chooses to pay three or four times as much as the intrinsic value of an article, it is, of course, at his option to do so; but, inasmuch as the main object of farming is a remunerative profit, it passes my comprehension to understand how that object can be gained by feeding animals on substances that cost from £40 to £50 per ton.

The above ingredients, throwing aside all the medical and flavouring compounds, give, upon analysis, the following results :—

Water	13·01
*Nitrogenous (or flesh-forming substances)	14·97
Fatty matter	5·78
Starch, sugar, &c.	54·40
Indigestible woody fibre	6·25
Mineral matter, ash	5·59
	100·00
* Equal to nitrogen	2·36

Such a mixture as the one represented by the foregoing analysis could be made by a mixture of barley-meal, beans, and oil-cake, at less than one-fourth of the price charged for the before-mentioned cattle-food. As to the stimulating properties contained in these foods, I am inclined to think their constant use is very questionable, and very likely to be productive of harm.

I have examined no less than four different descriptions of the advertised foods, in order to see whether they differed in composition to any great extent. They one and all contain full 90 per cent. of the ordinary foods of commerce. The following form the main ingredients used in the manufacture of two other cattle-foods now offered to the public: as they are both of the same character, it is only necessary to designate them as No. 1 and No. 2 :—

Constituents in 100 lbs. of—	No. 1.	No. 2.
Kidney-beans	20 lbs.	10 lbs.
Barley-meal	20 ,,	20 ,,
Oatmeal	20 ,,	20 ,,
Rice, ground	10 ,,	10 ,,
Linseed, ground	20 ,,	20 ,,
Peas	——	10 ,,
	90 lbs.	90 lbs.

The remaining 10 lbs. in the case of No. 1, comprise Peruvian bark, gentian, galingal, nitre, sulphur, resin, liquorice-root, caraway-seed, and common salt; and in the case of No. 2, cream of tartar, carbonate of soda, ginger, grains of paradise, and Iceland moss, are added to the composition.

These ingredients are not chosen without some degree of judgment;

but, as I have before observed, I very much doubt the propriety of giving these stimulants to cattle in their food, as in some conditions the use of some of them might prove injurious. The system here adopted forcibly reminds me of the old quack system of administering a draught to a patient, composed of a drop out of every bottle in the shop, when ordinary means had been exhausted without success.

APPENDIX D.

GAS-TAR.

In pursuance of the intention expressed at page 76, that I would test the effects produced on the growth of potatoes when manured with gas-tar, I now proceed to state the result:—

In the centre of a garden-plot planted with potatoes, in three rows, each about 30 feet long, about one gallon of gas-tar was distributed between the ridges. Some of them were recently dug up (9th August, 1860) and cooked: in flavour and quality they proved to be superior to others manured differently; and although not quite so large as usual, the yield is greater. It should be observed that the whole crop is partially diseased, inclusive of those manured with gas-tar; but the latter appear to be less so than the others. Next year the experiment will be repeated upon a larger scale, and an extra quantity of tar will be used.

COX AND WYMAN, PRINTERS, GREAT QUEEN STREET, LONDON.